December 1998

Vol. 22 No. 12

TECH BRIEFS

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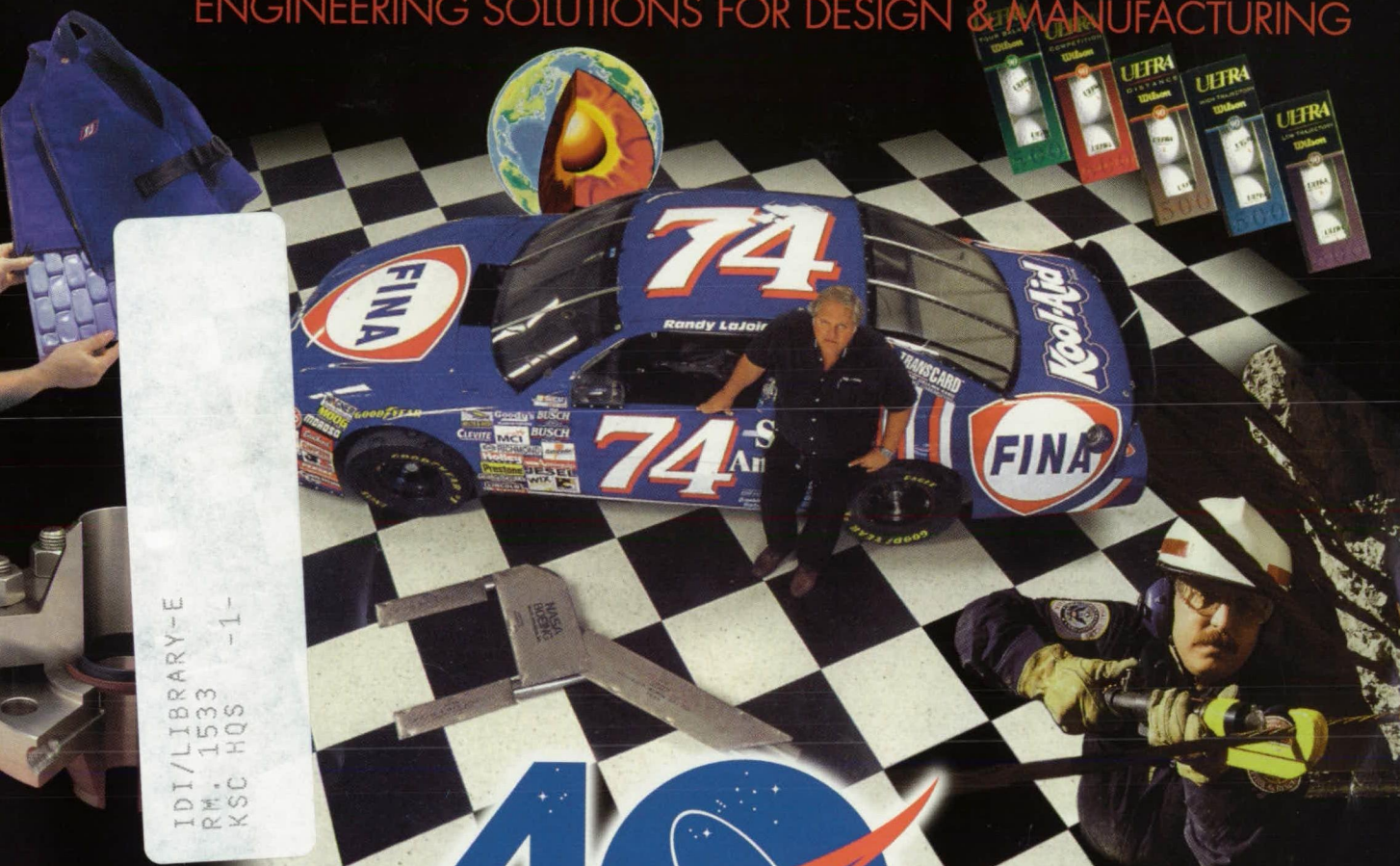
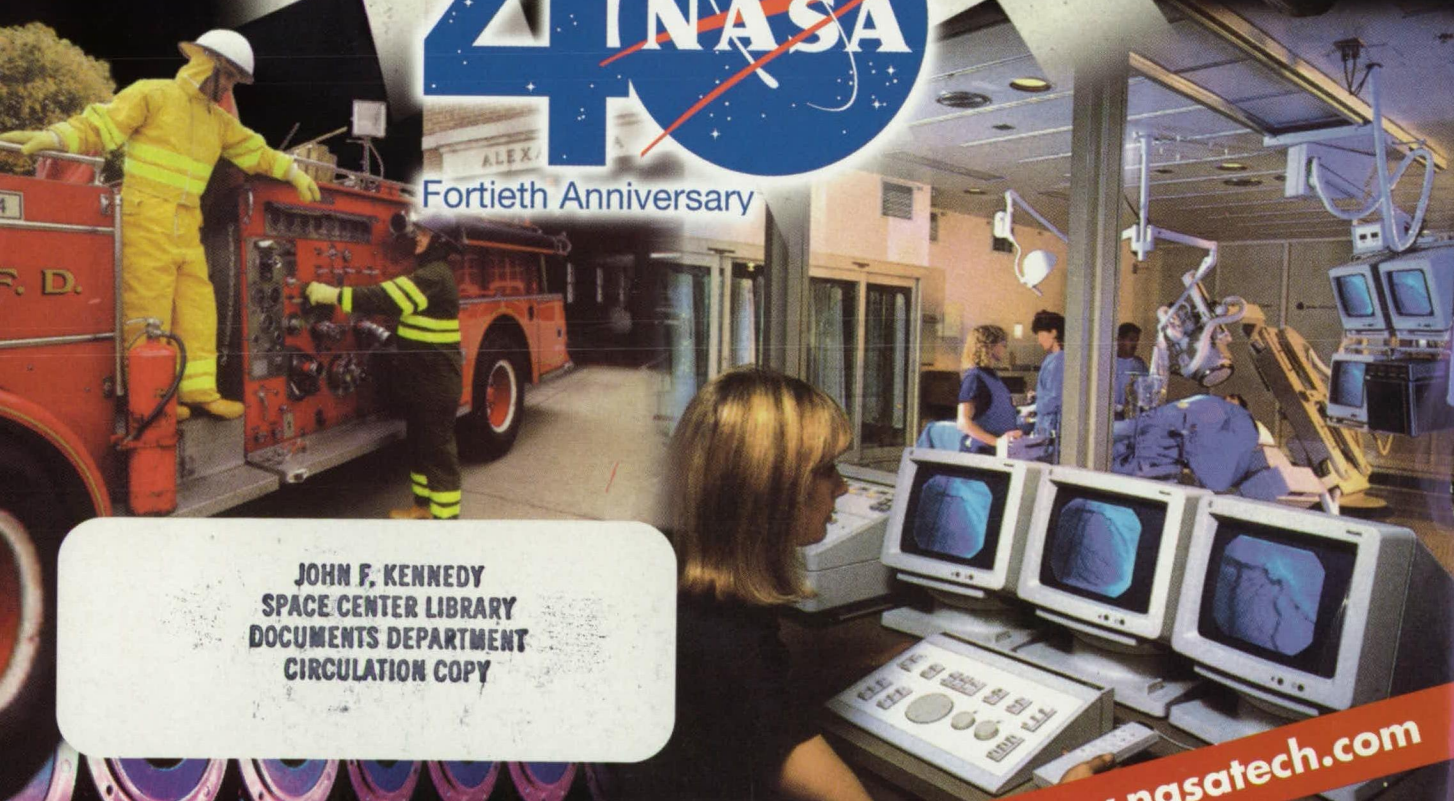


40 NASA

Fortieth Anniversary



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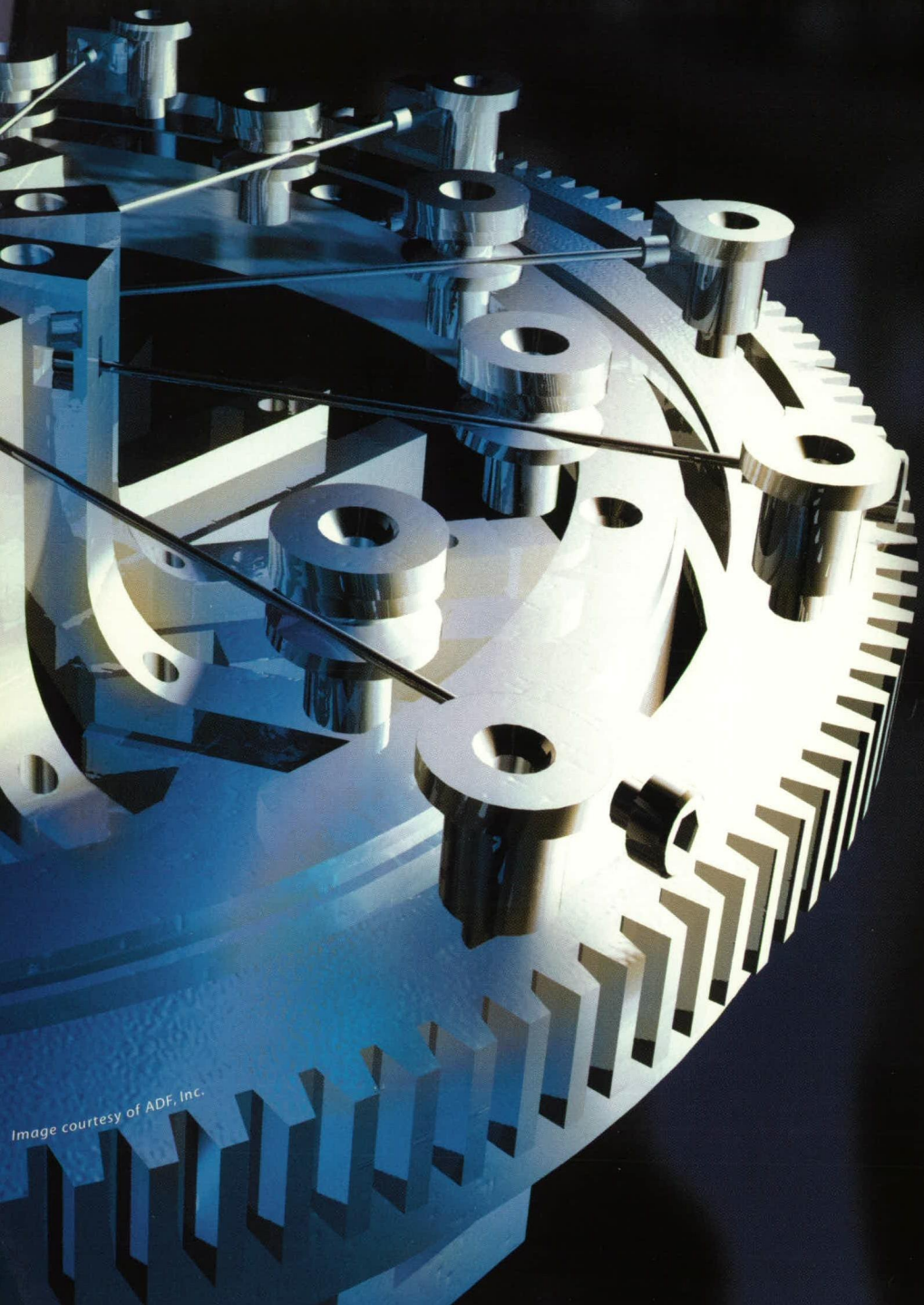

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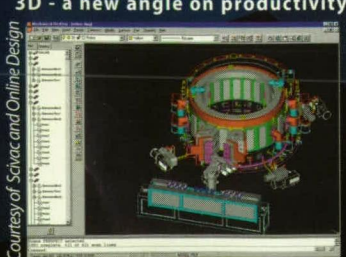

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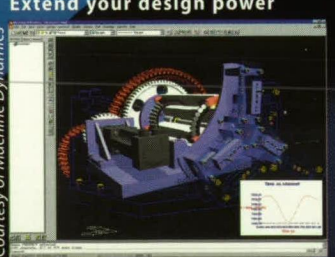

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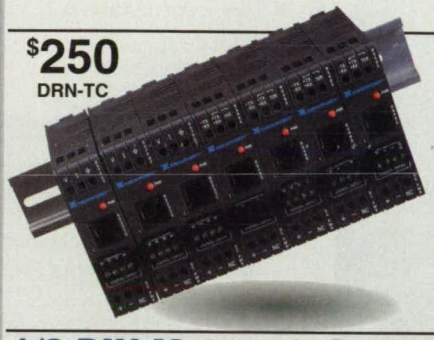

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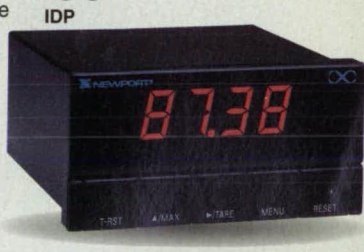

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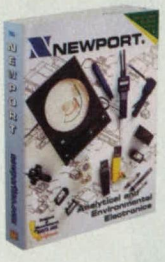

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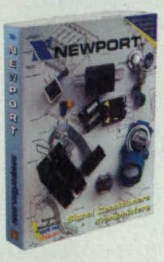

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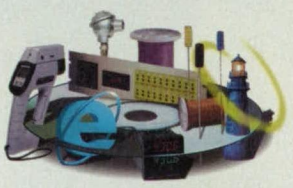

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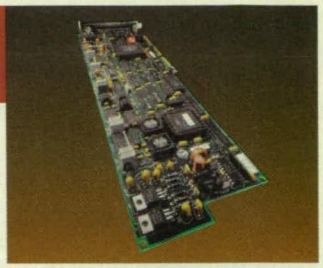

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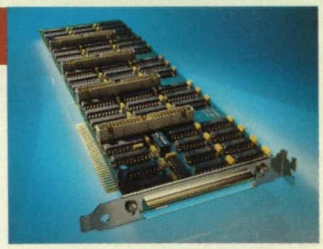

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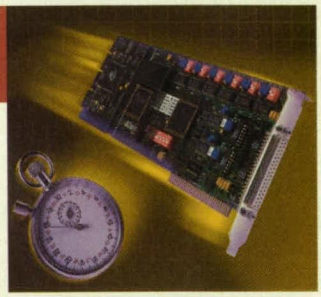

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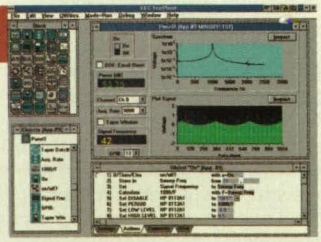

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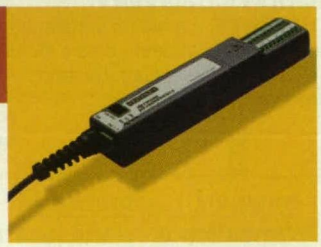

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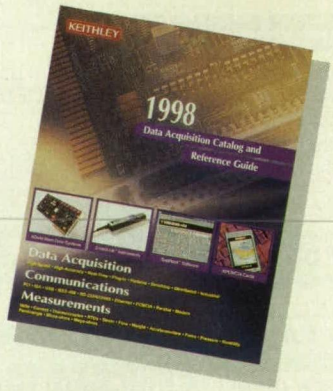

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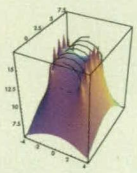

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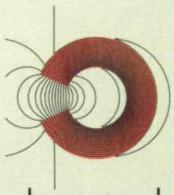

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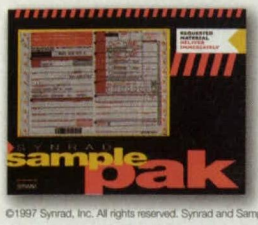

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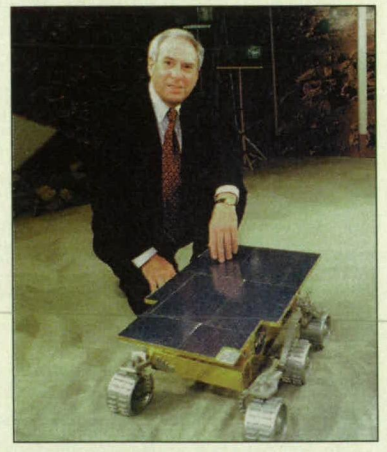
NASA TECH BRIEFS

December 1998 • Vol. 22 No. 12

Features

Briefs

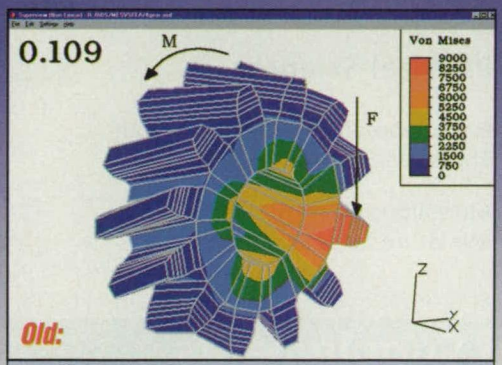
Departments



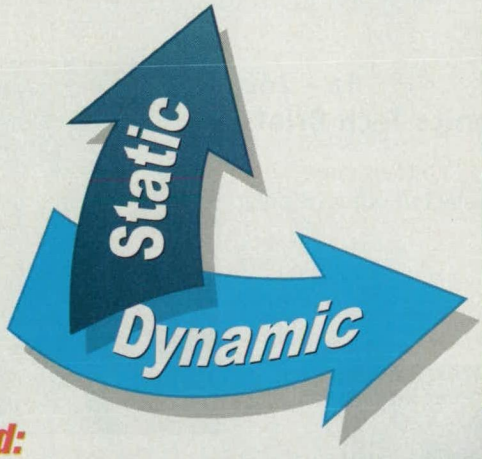
As the agency marked its 40th anniversary, NASA Tech Briefs *sat down with NASA Administrator Daniel S. Goldin for a candid interview. Mr. Goldin shares his views on NASA's greatest achievements, its most important technological contributions, and where he sees NASA heading as it begins its next 40 years.*

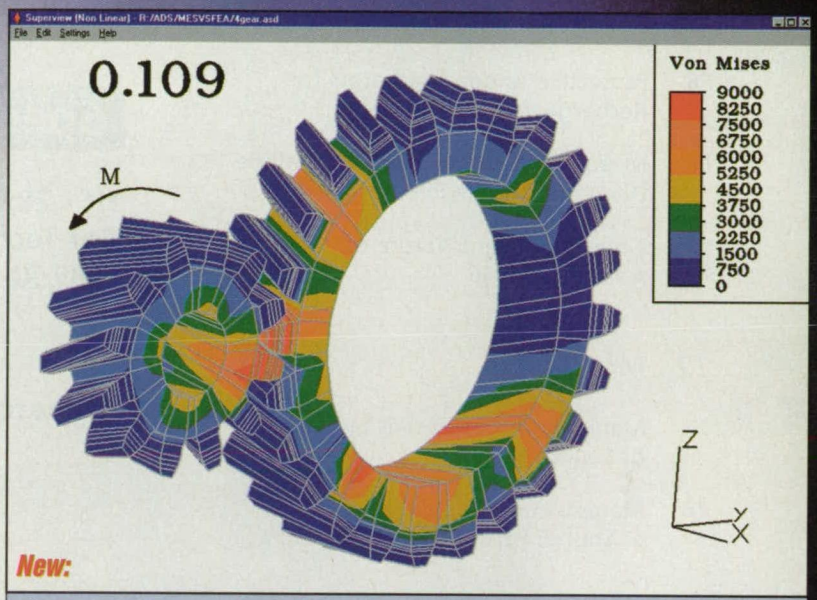
(Photo by Bill Ingalls; courtesy of NASA)

FEA Old vs. New



In Linear Static Stress Analysis, the forces must sum to zero. The effect of the second gear is simulated by an assumed force or pressure at a single instant in time.





In Algor's Mechanical Event Simulation, the forces sum to Mass times Acceleration (F=MA). Impact forces are transmitted through actual contact between the teeth during gear acceleration.

Old:

In traditional linear static stress analysis, you begin by building an FEA model. Then you set up boundary conditions to anchor the model in three-dimensional space.

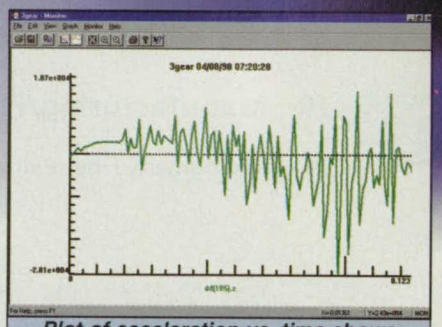
If the boundary conditions fail to stop the model from moving in all six primary directions (three degrees of freedom in translation and three in rotation), the static FEA process cannot work. After setting up the boundary conditions, you then apply the moment (M) or torque, which could be generated by an electric motor, and an assumed force (F) or pressure to simulate the reaction of the second gear. After analysis you will have a stress contour for one point in time.

Because the gear teeth are constantly clashing in a random way, the impact forces cannot be known with any precision.

New:

In Algor's Mechanical Event Simulation, you begin the same way by building an FEA model. However, this time you include the second gear.

You place boundary conditions at the pivots. The big gear is free to rotate when forced by the driving gear. Inertia of the entire gear system resists the force of the motor. When the analysis runs, you will know it's set up properly when you see the gears accelerating and stresses changing as you view the live on-screen "monitor program." At the end, you see the stresses on all the gear teeth at every point in time.



Plot of acceleration vs. time shows high-frequency impacts.

And, you can make an analysis replay to see the results in real time or slow motion. In addition, you can run a Fast Fourier Transform on the displacement data to highlight any dangers from resonance.

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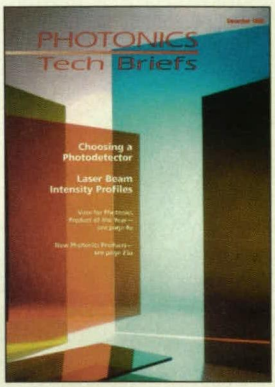
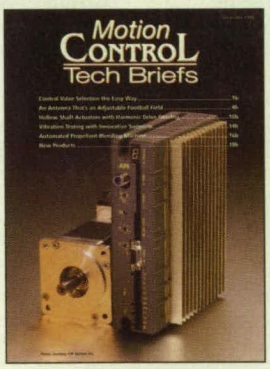
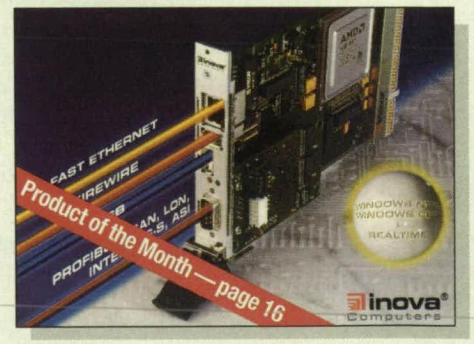




On the cover:

This issue marks the culmination of our year-long coverage of NASA's 40th Anniversary. Throughout the year, we've brought you 40 Years of NASA Innovations, a monthly series that celebrated the successful spinoff products and innovations that had their roots in NASA-developed technologies. From medical advances, to communications and manufacturing, to the environment and software, NASA technologies have led to products we use in our everyday lives. A sampling of those products is featured in the cover montage.



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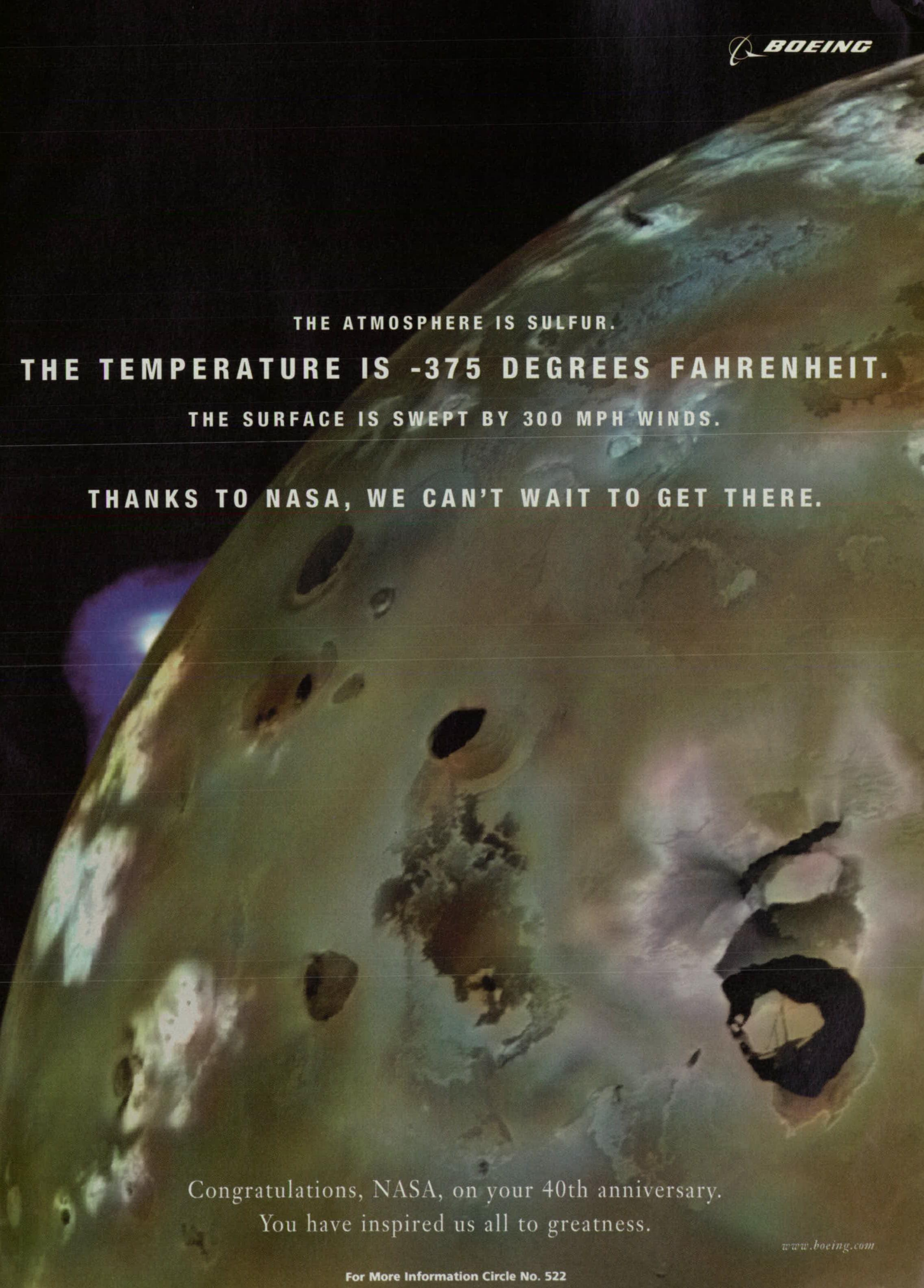

NASA Commercial Technology Team

NASA's R&D efforts produce a robust supply of promising technologies with applications in many industries. A key mechanism in identifying commercial applications for this technology is NASA's national network of commercial technology organizations. The network includes ten NASA field centers, six Regional Technology Transfer Centers (RTTCs), the National Technology Transfer Center (NTTC), business support organizations, and a full tie-in with the Federal Laboratory Consortium (FLC) for Technology Transfer. Call (206) 683-1005 for the FLC coordinator in your area.

NASA's Technology Sources

If you need further information about new technologies presented in *NASA Tech Briefs*, request the Technical Support Package (TSP) indicated at the end of the brief. If a TSP is not available, the Commercial Technology Office at the NASA field center that sponsored the research can provide you with additional information and, if applicable, refer you to the innovator(s). These centers are the source of all NASA-developed technology.

Ames Research Center
Selected technological strengths: Fluid Dynamics; Life Sciences; Earth and Atmospheric Sciences; Information, Communications, and Intelligent Systems; Human Factors.
Carolina Blake
(650) 604-0893
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Dryden Flight Research Center
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Goddard Space Flight Center
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galcorn@gsfc.nasa.gov

Jet Propulsion Laboratory
Selected technological strengths: Near/Deep-Space Mission Engineering; Microspacecraft; Space Communications; Information Systems; Remote Sensing; Robotics.
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merle.mckenzie@ccmail.jpl.nasa.gov

Johnson Space Center
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Kennedy Space Center
Selected technological strengths: Environmental Monitoring; Sensors; Corrosion Protection; Bio-Sciences; Process Modeling; Work Planning/Control; Meteorology.
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Langley Research Center
Selected technological strengths: Aerodynamics; Flight Systems; Materials; Structures; Sensors; Measurements; Information Sciences.
Dr. Joseph S. Heyman
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Lewis Research Center
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Larry Viterna
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Marshall Space Flight Center
Selected technological strengths: Materials; Manufacturing; Nondestructive Evaluation; Biotechnology; Space Propulsion; Controls and Dynamics; Structures; Microgravity Processing.
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Stennis Space Center
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NASA Program Offices

At NASA Headquarters there are seven major program offices that develop and oversee technology projects of potential interest to industry. The street address for these strategic business units is: NASA Headquarters, 300 E St. SW, Washington, DC 20546.

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NASA-Sponsored Commercial Technology Organizations

These organizations were established to provide rapid access to NASA and other federal R&D and foster collaboration between public and private sector organizations. They also can direct you to the appropriate point of contact within the Federal Laboratory Consortium. To reach the Regional Technology Transfer Center nearest you, call (800) 472-6785.

Joseph Allen
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Far-West Technology Transfer Center
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NASA's Business Facilitators

NASA has established several organizations whose objectives are to establish joint sponsored research agreements and incubate small start-up companies with significant business promise.

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Johnson Technology Commercialization Center
Houston, TX
(713) 335-1250

Wayne P. Zeman
Lewis Incubator for Technology
Cleveland, OH
(216) 586-3888

Joe Boeddeker
Ames Technology Commercialization Center
San Jose, CA
(408) 557-6700

Dan Morrison
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(800) 746-4699

NASA ON-LINE: Go to NASA's Commercial Technology Network (CTN) on the World Wide Web at **http://nctn.hq.nasa.gov** to search NASA technology resources, find commercialization opportunities, and learn about NASA's national network of programs, organizations, and services dedicated to technology transfer and commercialization.

If you are interested in information, applications, and services relating to satellite and aerial data for Earth resources, contact: Dr. Stan Morain, **Earth Analysis Center,** (505) 277-3622.

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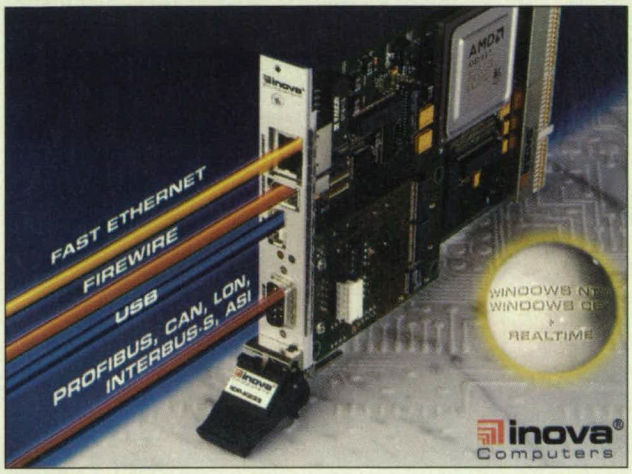


Inova Computers, Osterville, MA, has introduced the ICP-K233 line of 3U CompactPCI single-board computers that feature a 32-bit Pentium-compatible CPU, memory, graphic controller, real-time software options, and multiple communications options, including the high-speed FireWire interface. The boards, designed for embedded computing in industrial automation and control, robotics, environmental control, and other applications, feature the AMD K6 233-300 MHz processor. The boards provide up to 128 MB SDRAM and 24 MB FLASH RAM. A 256 kB or 512 kB pipelined burst static memory Level 2 cache also is included. For support of high-speed I/O devices, FireWire connectivity is included as a standard. Other communications interfaces include 10/100 MB Ethernet, 10baseT or 100baseTx networking, TCP/IP, and USB. A variety of real-time software to support the computers is available, including WindRiver's VxWorks.

For More Information Circle No. 733

NASA Study Yields "Hot" Results

Environmental planning for the 2002 Olympics, strategies to reduce ozone levels, focused tree planting programs, and identifying cool roofs are early spinoffs of a NASA urban study recently concluded in three U.S. cities. Researchers from NASA's Marshall Space Flight Center in Huntsville, AL, flew a thermal camera, mounted on a NASA aircraft, over Baton Rouge, LA; Sacramento, CA; and Salt Lake City, UT, taking each city's temperature. The thermal camera provided an image that pinpoints the cities' "hot spots." Researchers used the images to study what types of surfaces in cities contribute to bubble-like accumulations of hot air, called urban heat islands. These bubbles of hot air develop over cities as naturally vegetated surfaces are replaced with concrete, asphalt, and rooftops.

Thermal images, like this one of downtown Salt Lake City, UT, are being used to help plan sites for the 2002 Olympic Games. The white and red areas are hot, and generally correspond with roads and buildings; blue and green areas are cool and indicate water and vegetation.

The science team will continue to analyze the thermal heat information and work with the cities to implement future results.

For more information, contact Tim Tyson of NASA Marshall at 256-544-0994, or visit www.msfc.nasa.gov/news

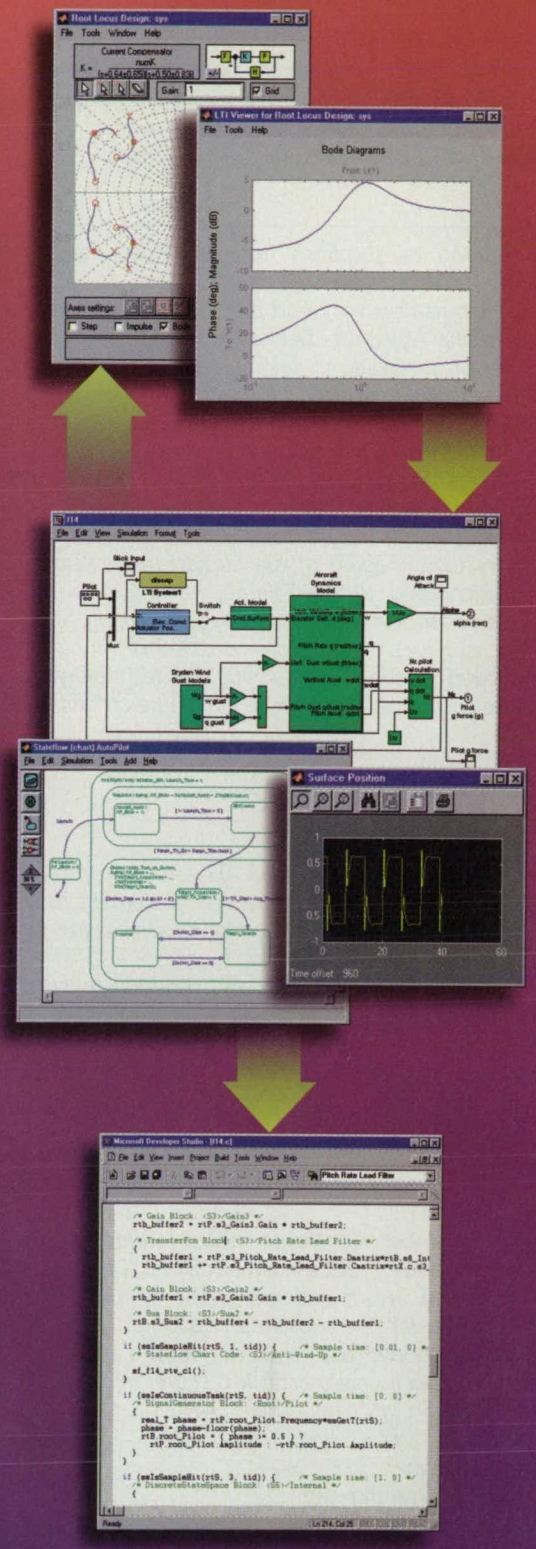
What's New On-Line

Resources of the *NASA Tech Briefs* (www.nasatech.com) and *Electronics Tech Briefs* (www.etbmagazine.com) web sites are being aggregated by CMP Media's EDTN (Electronics Design, Technology & News) Network (www.edtn.com) to provide users with access to a wealth of NASA-developed technologies available for commercial application. As part of the alliance, EDTN will aggregate key features of the *NASA Tech Briefs* web site, including the Technical Support Packages, which are free reports written by top NASA engineers and scientists detailing breakthrough technologies available to the U.S. engineering community. The ETB site will be designed to become a seamless part of the EDTN Network.

NASA Tech Briefs (NTB) and *Electronics Tech Briefs* (ETB — a Market Focus Edition of NTB that reports on advances in electronics) — are the latest sites to join EDTN's Network Partner Program, which aggregates sites with value-added content to provide its community of electronic design engineers and procurement business managers with the most comprehensive suite of technical information available on the Web. Other partners include *EE Times*, *Electronic Buyers' News*, *Semiconductor Business News*, and *Electronic Design*. CMP Media's OEM Group Publishing Director, Bill Barron, expects to announce similar agreements over the next few months.

The EDTN Network provides comprehensive, job-critical information for the electronics professionals, who have instant on-line access to everything they need to complete a project. Users can find a particular component, read the latest news and analysis about the component, and locate where they can purchase it.

With traffic that has ballooned to more than two million page views per month, the EDTN Network will cross-market with *NASA Tech Briefs* and *Electronics Tech Briefs*, and sell Network sponsorships. If your company is interested in on-line sponsorship opportunities, contact Luke Schnirring, director of electronic products, for *NASA Tech Briefs* on-line advertising (212-490-3999), or David Blaza, national Sales Manager, for EDTN Network sponsorship information (415-538-8895).



Flight control system example

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Reader Forum

Reader Forum is devoted to the thoughts, concerns, questions, and comments of our readers. If you have a comment, a question regarding a specific technical problem, or an answer to a question that appeared in a recent issue, send your letter to the address below.

I'd like to respond to questions from Jay Hagen and Srinath Kamineni that appeared in the October issue's Reader Forum. Both readers may find possible solutions to their problems in the November-December 1998 issue of MIT's Magazine of Innovation, Technology Review. *In response to Jay Hagen's request for information on airborne particulate, William Reent, a chemist at Lucent Technologies' Bell Labs, has put together an instrument to zero-in on particles as small as one-thousandth of a micrometer. This is a two-hundred-fold improvement over existing methods. Also included is information that could help Srinath Kamineni's search for non-invasive imaging of the human body. Xillix Technologies of Richmond, British Columbia, and Miravant Medical Technologies of Santa Barbara, CA, are working on an improvement to Xillix's imaging device called LIFE-lung, which was approved by the FDA in 1996. This technology uses certain wavelengths of laser light to illuminate organs.*

William Nesbit
Defense Logistics Agency

I volunteer at the Huntsville Hospital in Alabama. Recently, I was asked to help with a review of hospital equipment to find items that might experience Y2K problems. This volunteer committee is not expected to provide highly sophisticated technical knowledge; only practical and common-sense advice. Can anyone provide assistance about particular items or characteristics that we should be looking for? Any advice would be appreciated.

Norm Schlemmer
norms@hiwaay.net

I just read your October 1998 issue, which included the brief, "Robot Hands With Electroactive-Polymer Fingers" (NPO-20103, page 78). This is a clever, simple device with many applications. By far, the most marvelous part is the battery with three anodes and two cathodes. I always believed that the half-cell was practical. Is there any more information available on this component?

Marvin Forman
formanmarv@prodigy.net

*(**Editor's Note:** Marvin, you can find additional information at **www.nasatech.com** in the TS Packages area, under the Mechanics category.)*

Post your letters to **Reader Forum** on-line at: **www.nasatech.com** or send to: Editor, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017; Fax: 212-986-7864.
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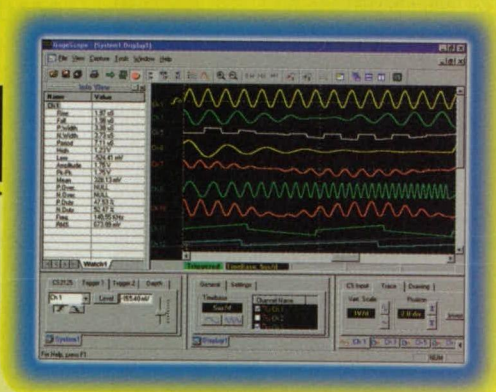

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NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Point Relay Scanner Utilizing Ellipsoidal Mirrors

(U.S. Patent No. 5,650,869)

Inventors: Paul K. Manhart and Robert J. Pagano, Jet Propulsion Laboratory

Scanners used in high-speed projection of point sources onto an image plane, as in Earth remote sensing, image scanning and projection, data display, and the like, generally require complex optics to ensure that the points being scanned are focused at a desired focal plane. This results in difficult and expensive design and in complex manufacturing requirements. Such scanners also experience some distortion and scan noise. The present invention provides a scanner utilizing a unique polygon of concave ellipsoidal mirrors. They rotate about an axis that contains one of their focal points, all of which lie on the axis at a common point. One or more point sources of light also reside at this point. The second of the two foci of the ellipsoid, conjugate to the first, rotates as the mirror assembly rotates, with the ellipsoid sweeping out a predefined arc. The scanning focal point is a substantially perfect replica of the source point without distortion or scan noise.

Method and Apparatus for the Collection, Storage, and Real-Time Analysis of Blood and Other Bodily Fluids

(U.S. Patent No. 5,665,238)

Inventors: Peggy A. Whitson and Vaughan L. Clift, Johnson Space Center

A difficulty encountered in analyzing many bodily fluids, such as whole blood, for disease is that the fluid actually is composed of both solid and liquid components. Whole blood is composed of two fractions, one a cellular fraction, which includes the various types of blood cells and any other relatively solid matter, and the other an acellular fraction, which consists of plasma or serum. Most of the analytes whose presence or concentration is used for clinical or laboratory purposes are contained in the latter. This invention is a simple, inexpensive method and apparatus for passively separating the fractions of clinically useful volumes of bodily fluids, for substantially simultaneously or subsequently analyzing these fluids for one or more analytes, and for prolonged preservation of the analytes. The apparatus includes a collection chamber bounded on its sides by an opening in a sheet of material abutting a filter card. The card is made of fibrous material treated with a carbohydrate-protein mixture and with a pore size of less than 3 microns. The blood or other fluid moves through the card by capillary action. The coating causes the cellular fraction to be trapped by the pores, while the acellular fraction passes through the filter for collection.

Flame Imaging System

(U.S. Patent No. 5,726,632)

Inventors: Heidi L. Barnes and Harvey S. Smith, Stennis Space Center

Hydrogen fires present a unique threat to personnel and equipment safety because the visible emissions are obscured by reflected solar radiation and thus invisible in daylight. But a hydrogen flame can be detected in several infrared regions, as can alcohol fires, typical hydrocarbon fires, and hot embers. The preferred embodiment of this device includes two charge-coupled-device (CCD) cameras. One, the "cloudy camera," uses an 800-nm long-pass filter that blocks sufficient background light during overcast conditions to make the hydrogen flame brighter than the background. The second, the "sunny camera," uses an 1100-nm long-pass filter that similarly blocks solar background in full sunshine. Two electronic viewfinders convert the signals from the cameras into a visible image. The operator can select the appropriate camera to use depending on light conditions. In addition, a narrow-bandpass filtered InGaAs sensor at 1360 nm triggers an audible alarm and a flashing LED if it detects a flame, providing additional detection means so that a very small flame is not missed.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 14 for a list of office contacts.

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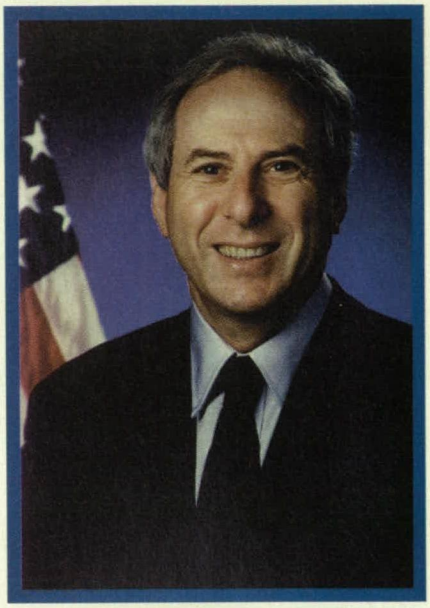
Daniel Goldin



Bill Ingalls/NASA

Daniel S. Goldin became the ninth NASA Administrator in April 1992, and immediately began to earn his reputation as an agent of change in bringing reform and revitalization to NASA. Goldin successfully brought NASA's budget process under control by finding ways to operate programs "faster, better, and cheaper" without compromising safety. Goldin developed new cooperative endeavors with the Russian Space Agency, spearheaded the redesign of the International Space Station, and identified environmental monitoring as one of the agency's most important programs.

No stranger to science and space technology, Goldin began his career as a research scientist at NASA's Lewis Research Center in Cleveland, where he worked on electric propulsion systems for human interplanetary travel. Prior to his appointment as NASA Administrator, Goldin was vice president and general manager of the TRW Space & Technology Group in Redondo Beach, CA. During his 25-year career with TRW, he managed the development and production of advanced spacecraft, technologies, and space science instruments.

As part of our final month of coverage of NASA's 40th Anniversary, *NASA Tech Briefs* spoke recently with Administrator Goldin about the challenges he's faced, the agency's role in the future of engineering, and how NASA will thrive in the next 40 years.

NASA Tech Briefs: **What do you view as NASA's greatest challenge today, and what do you see that becoming in the next 40 years?** (posed by NTB reader George Albrecht)

Administrator Goldin: To leave low Earth orbit behind to the commercial sector and have sustained presence beyond Earth's orbit, with both robots and people. And to utilize and develop cutting-edge information, electronics, and materials technology that will allow this to happen. Biological and biomimedical technologies, also.

NTB: You've said that engineering in America has become a "second-class citizen." What did you mean by that?

Goldin: In terms of long-term R&D investment. At the national level, we have a tendency to fund the long-term science, but we're not robust in funding the long-term technologies that are necessary to enable us. Our support for the engineering schools at the national level is not there. That is a crucial problem for the future of America as an economic power. Because if we don't have the cutting-edge technologies, instead of value-pricing we'll be locked in commodity pricing.

Take a look at modern aircraft. It's not value-priced. It's priced as a commodity. And there are price wars between Boeing and Airbus. The cost of aircraft has been going up for the last 20 years and the revenues have been going down, which is why you see these enormous problems in the airline industry. In the engineering field, we have to get the equivalent of Moore's law, which says that every year and a half you double the speed and cut the cost in half per bit, so it opens up new markets.

Without the long-term investment, it's not going to happen. NASA is one of the resources to ensure that we start reinvigorating (the engineering) field. This is why at NASA we are getting out of normal operations, we are getting out of routine things, and we are taking our limited budget and reinvesting it in high-risk, high-payoff technologies that will cause this resurgence to occur.

NTB: Recently, you spoke to NASA engineers about the need for a fundamental change in culture, and for Intelligent Synthetic Environments. Could you elaborate on that?

Goldin: In any major product development — corporations, the government — after we commit 90% of the resources, we may have only 10% design knowledge. And then, when there are problems, (the engineers) have to do redesign, rework, and retest. It's a very inefficient way of doing things and you cannot optimize a product if you don't have common databases, and you can't do real-time simulation.

So the thrust of Intelligent Synthetic Environments is to do high-fidelity, real-time, total immersion, virtual presence in a distributed manner, where instead of cutting a piece of hardware or writing a single line of code, you can completely develop a product in virtual space before you have to commit to costs. So then you're able to design the products with these new tools, which are physics-based design tools. When you run your simulations in virtual space, they are at any necessary level of fidelity. People are able to observe the same thing, they are able to integrate aerodynamics with electrical and with structures.

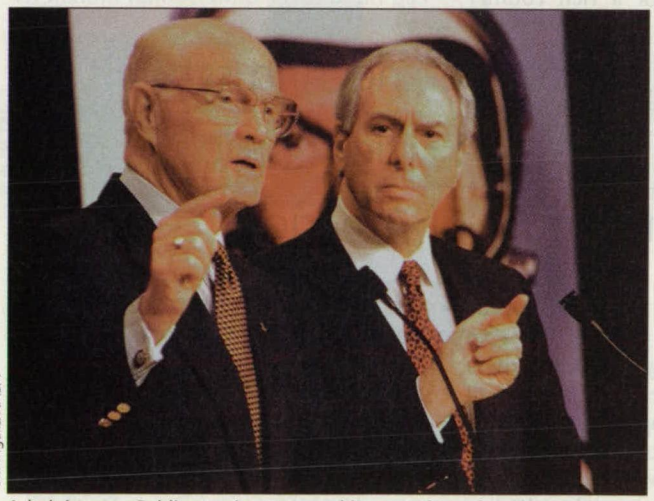
NTB: What is NASA's emphasis in helping this come about?

Goldin: Investing the money and providing the intellectual agents. It involves a broad set of fields ranging from getting away from numerical computing, deterministic computing, to biomimedics — mimicking biology.

Computers operate much too slowly. The fastest computer in the world is a million times slower than the brain. But the fastest computer in the world takes a megawatt. Your brain takes a few watts to operate at incredible speeds. So we have to understand how you can make faster computers.

If you take a look at how we do engineering today, we do curve-fitting and approximations. You want to start with the individual electrons and nuclei and work all the way up to integrated physical systems and physics-based tools. You'd like to figure out how to run simulations. How do you geographically distribute things so people see them at the same time? How do you get the fidelity so you can get a real view? How about not just having sight, but sound and touch and smell? How do you do it? What if you want to rub your hand across an edge and feel the temperature variations? So it is not just a neural net; it is not just a set of software codes. It is an integration of things. It is a whole change in the culture and the way we go about engineering.

"NASA would like to be able to make a significant contribution to improving the quality of life."



Bill Ingalls/NASA

Administrator Goldin was instrumental in returning John Glenn to space.

NTB: Will you have testbeds for this?

Goldin: We're going to have national testbeds — absolutely. We have a number of companies that are working with us on these testbeds. And these testbeds will grow in time. But this is not for this year or next year. This is over two decades.

NTB: Our readers benefit from NASA's tech transfer program. How essential to NASA's strategic mission is the commercialization and tech transfer program?

Goldin: NASA's about answering fundamental scientific questions. That's what drives us. When you start answering those questions, you come up with technologies and engineering tools that are well beyond what anyone can even dream of today, and then it's crucial that we take those tools and integrate them back into the economy and create economic wealth to pay for answering those fundamental questions.

We do the high-end, high-risk technology and then our (industry) partners do the product development so the taxpayers don't have to pay for the product development.

The industries are able to benefit from the high-risk technologies that they can't afford to develop, so it's a mutual admiration society.

NTB: You said that the cost and reliability of having access to space are the major barriers to opening up the space frontier. What is it going to take to get over some of those barriers?

Goldin: Developing the technologies so that we cut the cost by a factor of up to 50 to 100 from what it is today, and improve the reliability by a factor of about 10,000. That is absolutely essential. Just to open up space for defense of the nation, civil space exploration, and commerce, in terms of materials research, biomedical research, communications, weather, position determination — that's the minimum you have to do. Then if you want to have (space) tourism, you have to do another order of magnitude reduction of costs beyond that.

NTB: How do you get to that order of magnitude in cost reduction?

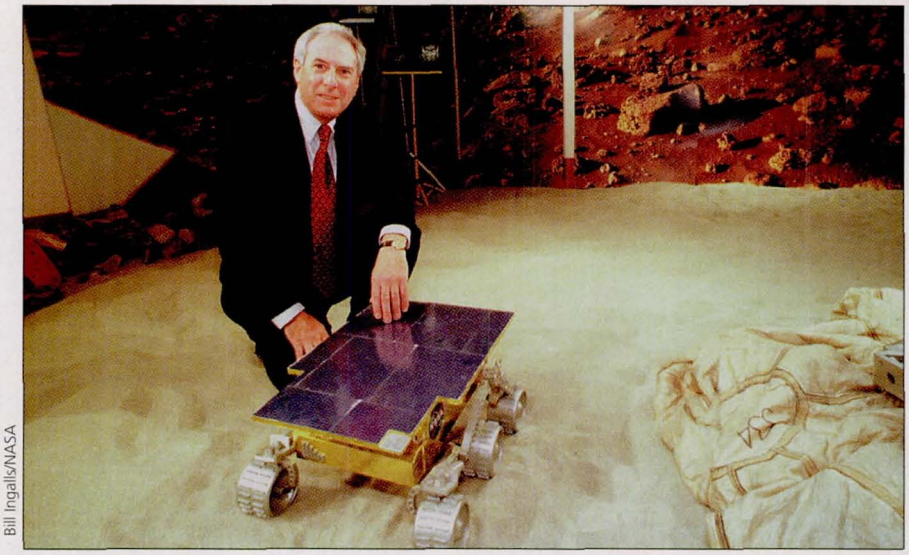
Goldin: The revolution in information technologies of the type we talked about in Intelligent Synthetic Environments. To have learning machines — machines that, like the human body, have a set of sensors able to detect problems in processes on-board, not on the ground. They'll be self-correcting. Distributed nervous systems, smart skins. They'll be able to validate where maintenance is required so you maintain by exception, rather than checking every box in the system. They will have advanced materials; they'll be air-breathing; and they'll have revolutionary systems concepts — very, very low-cost in nature — and they'll be simple so that they'll be reliable.

NTB: What do you think will be the most important contribution to life on Earth from the International Space Station?

Goldin: Improving understanding of the human anatomy so that biomedical researchers and biotech researchers working on the ground and in space will have a clear understanding of how the body works, so people will have a much healthier and more productive life. And as they age, they will age gracefully. Our estimate for life expectancy is going up, so with increased life expectancy, your quality of life should go up. We'd like to be able to, if it's possible, make a significant contribution to improving the quality of life through better medical care, better attention, better understanding of how the body works.

NTB: How do you convince the public that NASA and space travel are reasonable investments even in uneasy economic times?

Goldin: I don't think it's our job to convince the public. The public understands that. You cannot have a society that's enduring if that society only worries about their consumption and survival. We've seen through history that any society that concerns themselves with the present — any business that concerns itself with the present — and doesn't deal with the future, is a business or society that rapidly dies and evaporates. And as a nation, it is crucial that we make long-term, high-risk investments as part of our total investment package to ensure that a generation



Bill Ingalls/NASA

One of the most successful planetary missions of Goldin's tenure was the arrival on the Red Planet of the Mars Pathfinder— and the Sojourner rover, shown here — on July 4, 1997.

or two generations from now we have the tools and the intellectual stimulation. That the society will remain vibrant and strong economically, and strong knowing that no one will attack us. You've got to have a society of pragmatists and dreamers. You've got to have a society of people who are willing to take risks and have failure.

NASA is eight-tenths of one percent of the federal budget, and we're a tenth to two-tenths of a percent of the gross national product. It is a pittance. If you add up all the long-term research in America, you only come up with a few percent. It is woefully inadequate for a rich country like ours. Now, I go by the wisdom of the American people, and if that's what they want to spend, we're going to give them the maximum value for that small amount. We have a huge impact well beyond the eight-tenths of a percent of the budget. We touch almost every part of everybody's lives. If you just take a look at communications satellites, NASA has paid back to the American public many times what's been contributed. Weather satellites are the same thing.

You don't see (this payback), and that's why I said my dream is what the Space Station could do for Americans and people around the world. But when you do long-term, high-risk research, you can never predict the end result. But you know when you do it you have an amazing thing.

NTB: There's got to be a balance if you're looking long-term and stakeholders are asking, "what's the near-term benefit?"

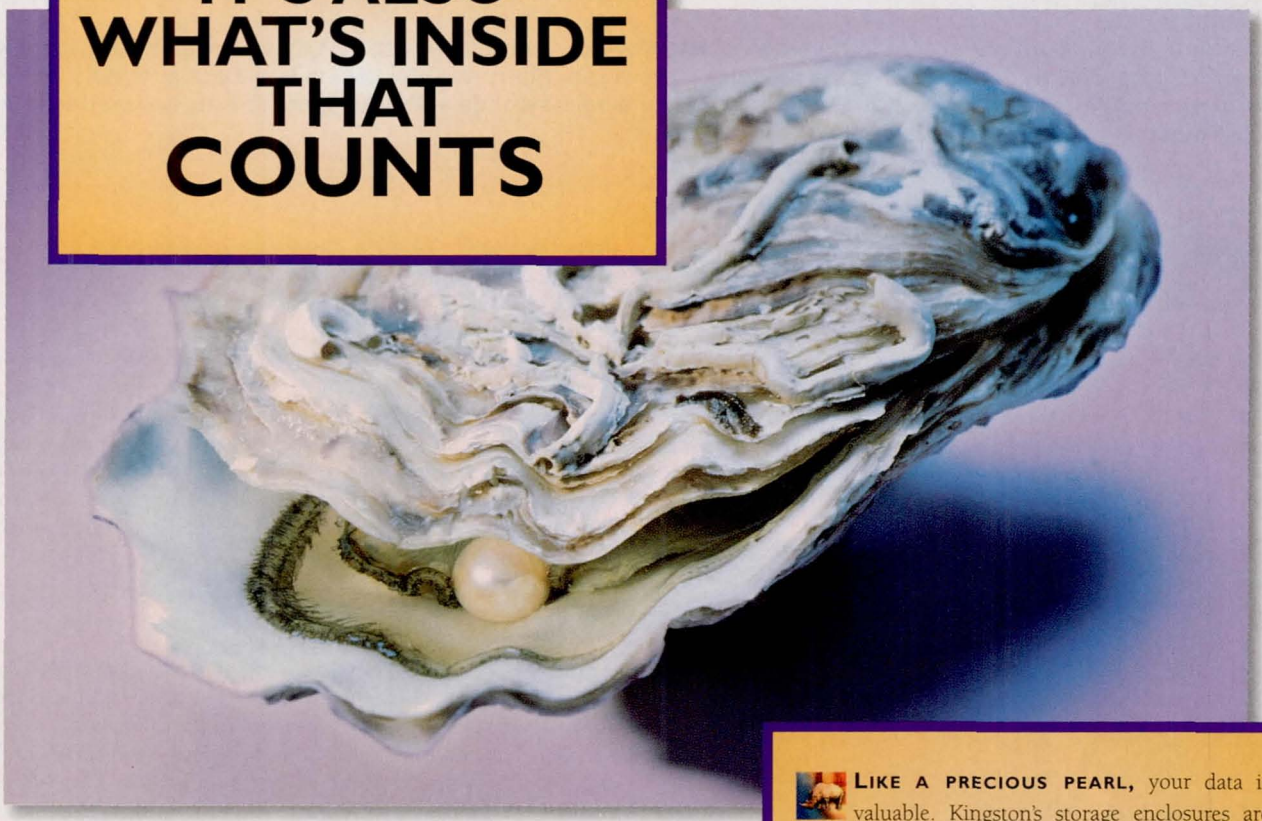
Goldin: We cannot tell them. We can tell them where we think it's going to be. We can't promise that we're going to cure cancer or solve heart disease. We won't do that. What we can say is that we know, by going into the absence of gravity, you learn more about the human anatomy. You're able to understand how the biological processes work in a different way. That we can say. We can build three-dimensional human tissue outside the body that we can't do on Earth. That we know. But what the outcome's going to be, I can't tell you. It would be intellectually wrong to predict the outcome.

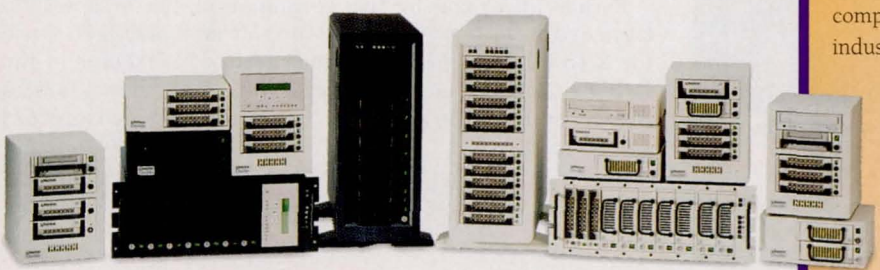
"Our support for engineering schools is not there. That is a crucial problem for the future of America."

NTB: What about NASA inspires you? (posed by NTB reader Kerem Durdag)

Goldin: Everything. There isn't anything about NASA that doesn't inspire me. The fact that the American people are willing to spend billions of dollars a year on technologies that have no guaranteed end results, that are high-risk, to rewrite chemistry, physics, and biology textbooks and stimulate the imaginations of young and old alike to me is the inspiration. It's the statement that the American people care about their future.

IT'S ALSO WHAT'S INSIDE THAT COUNTS





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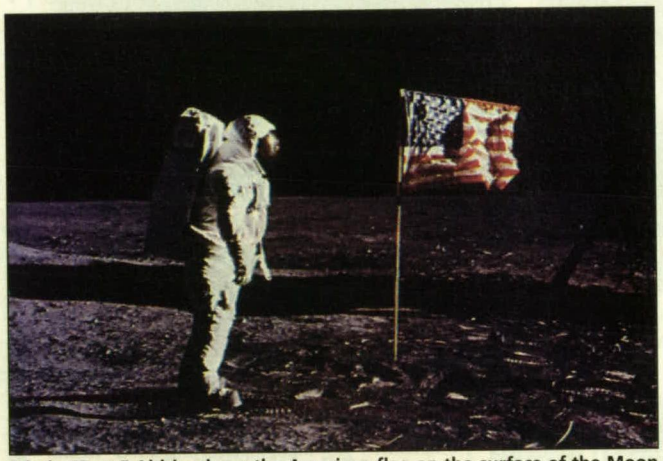
This month we wrap up our year-long coverage of NASA's 40th Anniversary with NASA's advances in Aerospace and Aeronautics, including technologies that may revolutionize future flight. We also take a look back at NASA's achievements in space exploration and space flight, and how technological wonders like the Space Shuttle have led to — and will continue to produce — benefits to life on Earth.

1950s – 1960s

A Giant Leap

The National Aeronautics and Space Administration was officially "born" on October 1, 1958, absorbing into it the National Advisory Committee for Aeronautics (NACA), its predecessor. NASA emerged in part because of national defense concerns during the cold war with the Soviet Union, and began to conduct space missions within months of its creation. In its 40 years, NASA has made historic achievements in many areas of aeronautics and space research. Some of the most well-known have been Projects Mercury, Ranger, and Gemini in the 1960s, the lunar missions of Apollo in the 1960s and 1970s, and the Space Shuttle program (see below) of the 1980s and 1990s.



Edwin "Buzz" Aldrin places the American flag on the surface of the Moon as Neil Armstrong snaps this historic photo.

On May 5, 1961, Alan B. Shepard, Jr. became the first American in space aboard the Mercury-Redstone 3 *Freedom 7*. Shepard's 15-minute, 28-second suborbital flight would precede by eight months the flight of the Mercury-Atlas 6 *Friendship 7* on February 20, 1962 — the flight that lasted just under five hours and made John H. Glenn the first American in orbit.

Following the successes of the Mercury program, NASA set its sights on the Moon. The Ranger series of missions from 1961 to 1965 was the first U.S. attempt to obtain close-up images of the Moon. The Ranger spacecraft were designed to fly straight down towards the Moon and send images back until the moment of impact. From 1966 to 1968, the Surveyor probes became the first U.S. spacecraft to land safely on the Moon. Their main objectives were to obtain close-up images of the lunar surface, and determine if the terrain was safe for manned landings.

The Apollo program, which was conducted from 1963 to 1972, was designed to land humans on the Moon and bring them back safely. Apollos 7 and 9 were Earth-orbiting missions to test the Command and Lunar Modules; Apollos 8 and 10 tested various components while orbiting the Moon, and returned photography of the lunar surface.

Then, on July 20, 1969, Apollo 11 landed on the Moon's Sea of Tranquillity and Neil Armstrong became the first person to walk on the lunar surface. Five subsequent Apollo missions also landed on the Moon. These six missions returned a wealth of scientific data and almost 400 kilograms of lunar samples. Experiments included soil mechanics, meteoroids, seismic, heat flow, lunar ranging, magnetic fields, and solar wind experiments.

Pushing the Boundaries of Flight

In 1959, test pilots began taking the rocket-powered X-15 to the outer reaches of Earth's atmosphere. This missile-shaped research aircraft provided in-flight data on aerodynamics, structures, flight controls, and the physiological aspects of high-speed flight at altitudes of more than 40 miles. It also was used as a testbed to carry scientific experiments beyond the atmosphere.

Because of its massive fuel consumption, the X-15 was air-launched from beneath a B-52 aircraft at 45,000 feet. Once the X-15 was on its own, it topped speeds of 4,500 mph — the fastest a winged vehicle had ever flown. There were 199 X-15 flights between 1959 and 1968. The aircraft reached a record altitude of 67 miles.

1970s – 1980s

The Shuttle: A Link to the Potential of Space

On April 12, 1981, Commander John W. Young and Pilot Robert L. Crippen took the Orbiter *Columbia* — and NASA's hope for a new era in space history — into orbit with the launch of STS-1, the first Space Shuttle mission. The principal element of NASA's Space Transportation System (STS), the shuttle was conceived with a space station in mind; it would enable a permanent station in space to be built in modular fashion by delivering the necessary elements. Designed to reduce costs and make access to space a matter of routine, the Space Shuttle program gave NASA a new way to pursue the Earth benefits offered by space, and gave the American people a taste of the enormous possibilities for harnessing the scientific breakthroughs that could be waiting in space.

The shuttle opened the door to in-orbit manufacturing of products that are better produced in space, and to the assembly of habitable space settlements such as the International Space Station. On November 28, 1983, NASA launched a milestone mission of the Space Shuttle Orbiter *Columbia*, with

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The first Space Shuttle flight, *Columbia*, blasts off from Kennedy Space Center on April 12, 1981.

Spacelab 1 on board. The initial launch of the Spacelab pressurized flying laboratory also marked the first time that a non-American astronaut, payload specialist Dr. Ulf Merbold of West Germany, flew aboard a U.S. spacecraft.

Spacelab's first mission, which lasted nine days, conducted more than 70 separate investigations in five areas of research: atmospheric physics and Earth observations, astronomy and solar physics, space plasma physics, life sciences, and materials processing in the near-zero-gravity environment. A special group of experiments studied the interaction between a human's vestibular system and the brain, in order to understand the causes of motion sickness and sensory motor adaptation to weightlessness.

Three significant shuttle missions in preparation for the International Space Station occurred in the 1990s, beginning with the June 29, 1995 docking of *Atlantis* with the Russian Mir Space Station 161 miles above the Russian border. The mission marked five days of cooperative Russian/American experimentation in the linked *Atlantis*/Mir, the largest structure ever assembled in orbit. *Atlantis* was launched again to Mir on March 24, 1996, docked with it, and the six-astronaut crew of shuttle flight STS-76 joined three cosmonauts on the station. Among the Americans was mission specialist Shannon Lucid, a veteran of five shuttle flights, who was reporting for duty on Mir as a cosmonaut researcher. Lucid would spend almost six months on Mir, returning on the September 16, 1996 flight of Atlantis. Lucid's arrival at Mir kicked off a two-year span of continuous U.S. presence in orbit, which came to an end with the ninth and last U.S./Mir docking mission, STS-91, *Discovery*, which launched on June 2 of this year.

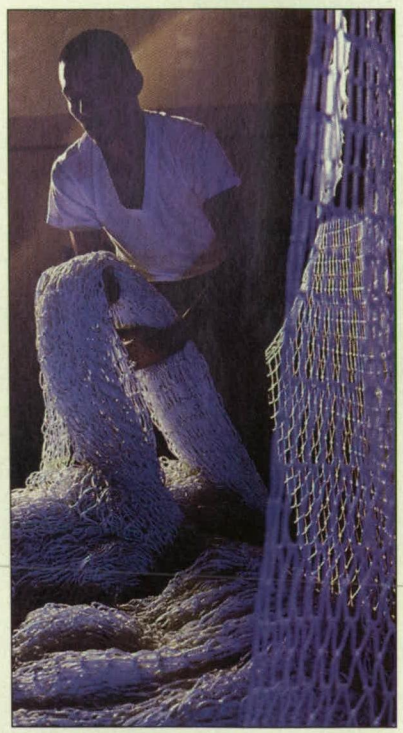
Shuttle Spinoffs

The Space Shuttle ensured that space would no longer be the exclusive province of highly-trained astronauts. It would allow scientists and other specialists to perform experiments, study the heavens, and relay information about life on Earth.

Microspheres — The first products made in space were introduced to the commercial marketplace in 1985. These "microspheres" are plastic beads so tiny that a vial containing 15 million of them is no larger than an index finger. Each is a perfect sphere with a diameter of 10 micrometers — 1/2500th of an inch or 1/40th the diameter of a human hair — and all are identical in size. They fill a need among research and industrial labs as a reference standard for calibrating instruments such as microscopes and automatic blood cell counters with extreme accuracy. Made of polystyrene — the material used in disposable drinking cups — the microspheres were made on four Space Shuttle flights from 1982 to 1984. The program demonstrated the ability to process materials in the gravity-free environment of space to manufacture products that cannot be produced on Earth. Among those products are advanced medicines; semiconductor materials with improved electrical properties; pure glass for applications such as lasers and optical systems; and superior metal alloys for a variety of applications.

Insulation — While experiments conducted on-board the shuttles have led to the development of products and procedures for use on Earth, it is the Shuttle Orbiter itself that has generated spinoff technologies. One prime component of the shuttle Orbiters is the Thermal Protection System (TPS), a mosaic of thermal insulating tiles that protects the Orbiters from searing re-entry heat that can reach 2300°F. This TPS has served as the basis for a number of commercially manufactured insulating materials over the past decade. NASCAR racing teams began using the insulating material to shield drivers from the dangerously high temperatures in the car's cockpit during a race. By covering hot spots in the car with the insulation, temperatures in the driver cockpit have been reduced by up to 90°. Aircraft, commercial ovens, and other automotive applications also use the Space Shuttle insulating material.

Safety Netting — In 1979, West Coast Netting (WCN) of Rancho Cucamonga, CA, was contracted to develop a safety net for personnel working on the shuttle Orbiter. Several such nets would be used to prevent workers from falling through an open engine cavity to the ground. WCN chose Nomex®, a polyester-like material that could be treated for ultraviolet resistance. A twine made of multiple layers of the fiber twisted together resulted in the super-twine that met NASA's specifications. A net made of it can sustain a load of 800 pounds falling 25 feet.

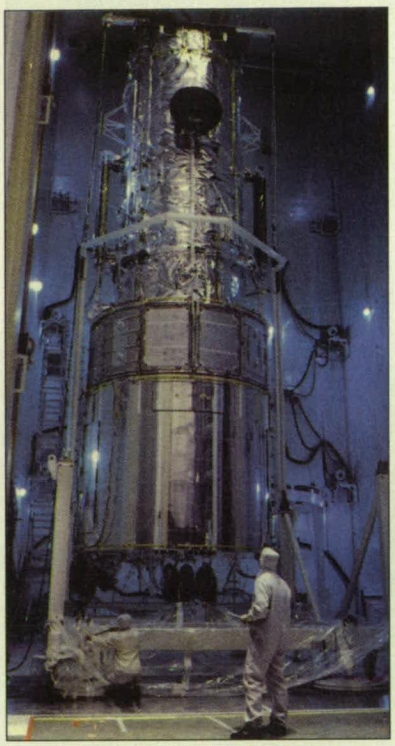


The Hyperester Seine fishing net was developed from Space Shuttle safety netting.

The nets offered obvious application in the fishing industry. The twine is very dense and absorbs less water, causing it to sink faster and fish deeper. WCN's Hyperester™ Seine net hit the market in 1983, providing a boon to a hard-pressed fishing industry whose operational costs had escalated enormously

Back to the Future: The Hubble Space Telescope

Named for Edwin P. Hubble, the American scientist whose discoveries and theories of the 1920s revolutionized the study of astronomy, the Hubble Space Telescope was deployed from the shuttle on April 25, 1990. Since the 1960s, NASA has orbited a number of small space-based telescopes, but nothing close to the sophisticated Hubble, which can peer seven times farther into space than the largest Earth telescope.



Launched in 1990, the Hubble Space Telescope has allowed scientists to see up to 14 billion years into the past, to the origins of the universe.

Because light from distant galaxies takes so long to reach us, the Hubble has literally allowed scientists to look back into time — as far as 14 billion years ago. Estimates as to the age of the universe range from 12 to 20 billion years; when observing the most distant celestial objects, the Hubble captures light that began its journey when the universe was in its infancy. The 12-ton telescope measures 43 feet long and operates above the atmosphere at 370 miles. Developed by Lockheed and Perkin-Elmer, the Hubble is controlled by scientists at the Space Telescope Science Institute in Baltimore, MD. The Institute is operated for NASA by the Association of Universities for Research in Astronomy.

Technology from the Hubble project already has proved beneficial to life on Earth. An advanced, sensitive Charge Coupled Device (CCD), developed for the Hubble by Scientific Imaging Technologies, has contributed to a new, non-surgical and less traumatic breast biopsy technique, which is replacing surgical biopsy (see Nov. 1998 *NASA Tech Briefs*, p.28).

Improvements in Aircraft Design

Dr. Richard T. Whitcomb and a team of researchers at NASA's Langley Research Center developed a series of "supercritical" wings during the early 1970s. The supercritical wing is an advanced airfoil that is flattened on the upper surface. The trailing edge trails downward. This design delays the buildup of air drag at high speeds, allowing the aircraft to fly faster on the same amount of fuel.

The NASA Aircraft Energy Efficiency (ACEE) program, which began in 1975, introduced several advances in aerodynamic technology, including "winglets" — vertical wing extensions that reduce air drag and improve aircraft performance.

The XV-15 tiltrotor has helicopter-like rotors for vertical takeoff, hovering, and landing.

NASA also began experimenting with propulsion technology and aircraft design that would help relieve airport congestion and reduce aircraft noise.

In 1981, the XV-15 research aircraft was built by Bell Helicopter Textron under joint sponsorship of NASA and U.S. Army Research and Technology Laboratories. This V/STOL (Vertical Short Take Off and Landing) aircraft combined the capabilities of a helicopter with the greater forward speed of a fixed-wing airplane. The XV-15 is also known as the "tiltrotor" aircraft: It has two large rotors to provide vertical lift. Once airborne, the rotors tilt forward to become propellers for cruise flight.

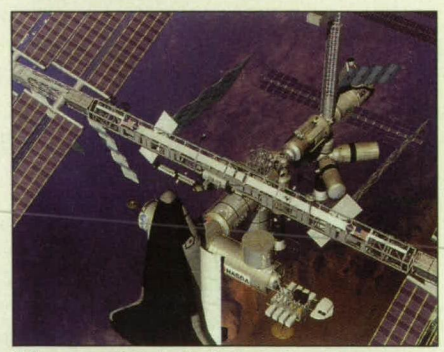
Potential military applications included troop or supply transport, reconnaissance, and rescue. In civilian use, the V/STOL could be used as a short-haul commuter liner or as a utility aircraft for transporting workers to offshore oil rigs.

1990s

Tomorrow in Space

The International Space Station (ISS) is the largest cooperative scientific project in history, combining resources and technological input from 16 nations. Conceived almost 30 years ago as "the next logical step" to follow the Apollo program, the station became a formal NASA project in 1984, when President Reagan established the goal of developing a permanently inhabited outpost in space. Initially called Space Station Freedom, it was redesigned in 1993 after budget constraints.

Construction of the ISS will be the most complex activity ever conducted in orbit, posing enormous technological and logistic challenges. The entire station will be assembled on the fly without the advantages of ground assembly and checkout.



When completed, the International Space Station will measure almost 360 feet and be visible to the naked eye.

During complex extravehicular activities (EVAs), astronauts and cosmonauts will join the separate components into a single, orbiting laboratory with crew quarters, solar arrays, a rescue vehicle, and life-support systems.

The mission of the space station

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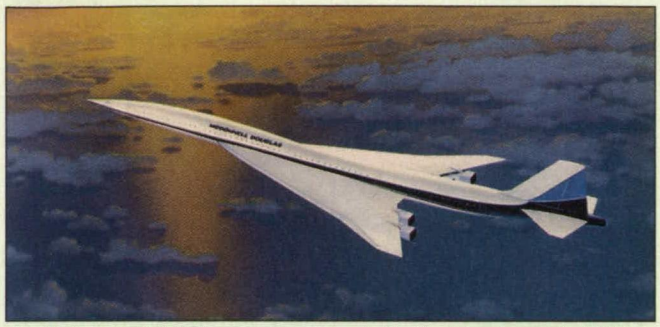
project has remained virtually unchanged over years of redesign and postponement. It will serve as an orbiting laboratory and operations base. As a lab, it will permit long-duration observations of the land and oceans for scientific, commercial, and defense purposes, or scientific observations in the opposite direction — toward the Sun, the planets, and the stars. It will be a science institute capable of supporting long-term research in life sciences and materials in a nearly gravity-free environment, and it will house medical research and other breakthroughs in technology and engineering that will have immediate, practical applications for life on Earth. Testing of life-support systems and other technologies may also serve as "dress rehearsals" for future lunar and Mars habitation.

Scheduled to be constructed in a series of three phases, the final assembly launch is now targeted for January 2004. By the time it is completed, the entire ISS will measure almost 360 feet from tip to tip of the solar arrays — the length of a football field, including both end zones. It will weigh 470 tons, operate at an average altitude of 220 miles above Earth, and be visible to the naked eye.

Toward 21st-Century Flight

NASA Administrator Daniel Goldin has outlined a plan for NASA to increase aeronautics funding and to help assure future U.S. competitiveness in aviation. The first priority is the High Speed Research program, which focuses on the environmental concerns of supersonic transport. Researchers are working on advanced combustion concepts to reduce ozone-depleting engine emissions of nitrogen oxide. Using research aircraft and satellites, NASA collects data to develop, test, and evolve computer models that estimate the impact of emissions on the atmosphere. In developing a 21st-century High-Speed Civil Transport (HSCT), the goal is to cut nitrogen oxide emissions by 90 percent.



The High-Speed Civil Transport program is the first step toward a 300-passenger supersonic plane.

The next-generation HSCT probably will be only moderately faster than the Concorde supersonic transport now in airline service. But the new supersonic transport will probably have double the Concorde's range and carry three times as many passengers.

NASA's second priority is to assist in establishing a new air traffic control and communication system to be incorporated into a fleet of advanced subsonic aircraft. The third priority is to upgrade national aeronautics facilities to better support aviation research.

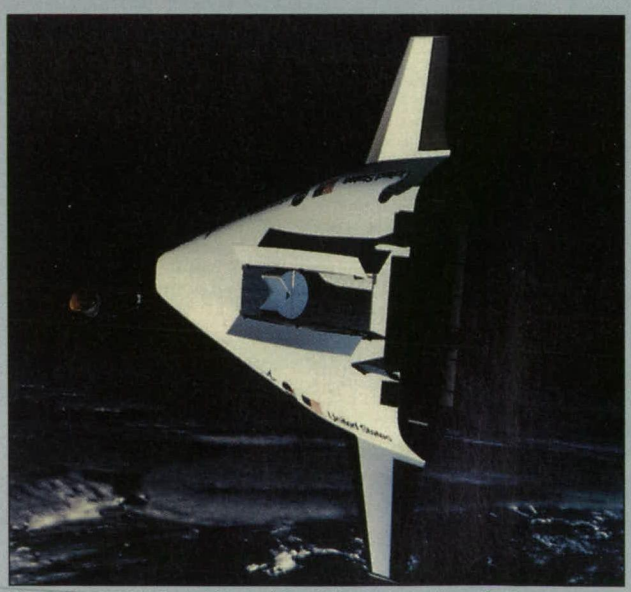
NASA has conducted several hypersonic exploratory investigations, including the X-30 concept jointly developed with the Department of Defense. The X-30 is designed as a "lifting body" — its fuselage is designed to provide aerodynamic lift.

Since 1976, *Spinoff* has featured many down-to-earth applications of NASA technology. To learn more about how NASA technologies affect our everyday lives, visit the *Spinoff* web site at: www.sti.nasa.gov/tto/spinoff.html

Looking Ahead ...

• Like the X-15 of the 1960s, future space vehicles will be hybrids combining the best of airplane and rocket technology. Engineers at NASA's Marshall Space Flight Center are using high-temperature ceramics and strong, lightweight composites to develop more cost-efficient space-propulsion systems. The Fastrac, a simple turbopump rocket engine with relatively few parts, will cost about $1.2 million — about one-fifth the cost of similar engines. It provides 60,000 pounds of thrust to boost payloads of up to 500 pounds. The first vehicle scheduled for the Fastrac is the X-34 reusable launch vehicle (RLV), a technology testbed for future low-cost spaceplanes.

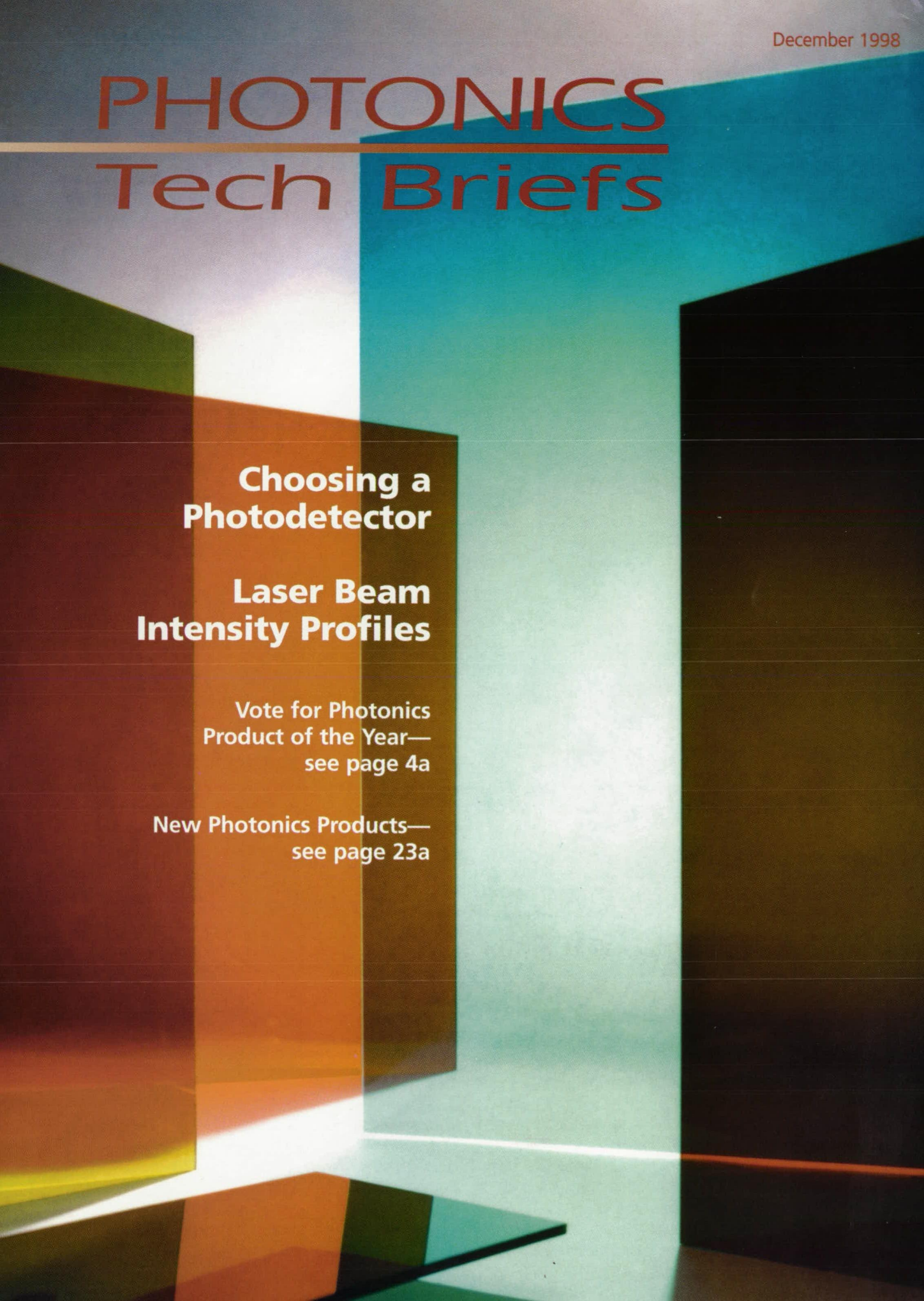
• The X-33 Reusable Launch Vehicle, developed by NASA and Lockheed Martin Corp.'s Skunk Works, is designed, according to NASA Administrator Daniel Goldin, "to take days, not months, to turn around; dozens, not thousands, of people to operate; with launch costs that are a tenth of what they are now. Our goal is a reusable launch vehicle that will cut the cost of getting a pound of payload to orbit from $10,000 to $1,000." The vehicle is designed to replace the Space Shuttle in the 21st century. The X-33 is a wedge-shaped lifting body type of vehicle in which the entire airframe, not just the stubby winglets, generates lift. It is designed to be launched vertically and land horizontally, like the Space Shuttle, but where the shuttle uses conventional engines, a large throwaway fuel tank, and drop-off boosters for launch, the X-33 will be totally reusable and employ "aerospike" engines. The system does not use conventional bell-shaped engine nozzles, but automatically compensates for decreasing atmospheric pressure and regulates thrust as the vehicle ascends.



The X-33 RLV, designed by Lockheed, is set to replace the Space Shuttle in the 21st century.

December 1998

PHOTONICS Tech Briefs



Choosing a Photodetector

Laser Beam Intensity Profiles

Vote for Photonics Product of the Year—see page 4a

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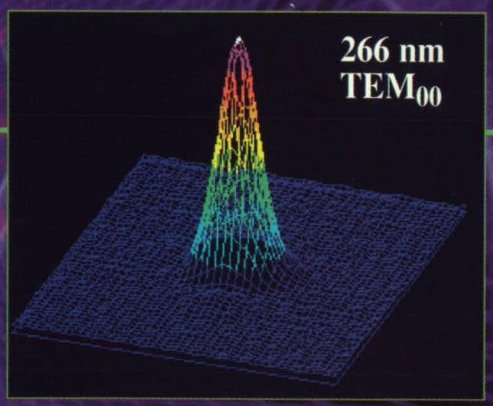

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Wait a Minute... Who's Kobayashi?

OptoSigma's Mitsuo Kobayashi is a dreamer. He didn't discover gravity or a new moon, but awoke early one morning with a revolutionary new concept in opto-mechanical positioning. After a few quick sketches, he rushed to work. It didn't take long for us to realize that his extended contact bearing stage was an astronomical leap forward. The rest is history.

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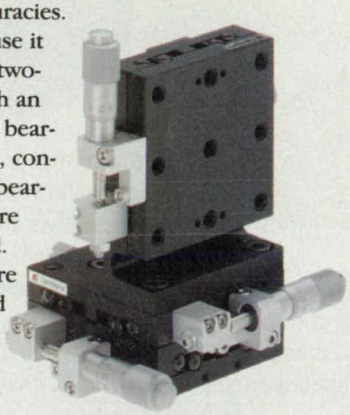

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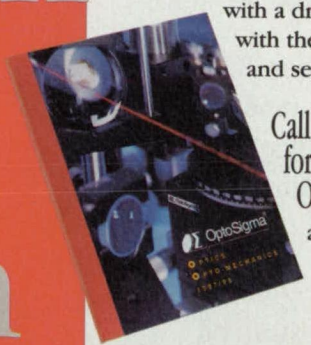

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Supplement to *NASA Tech Briefs'* December 1998 Issue
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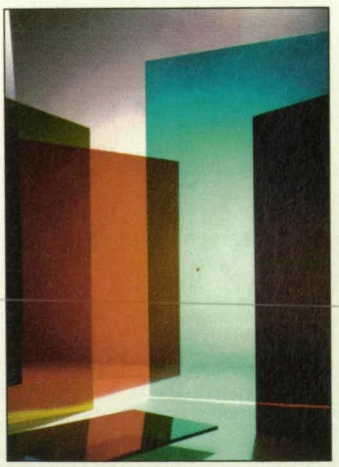
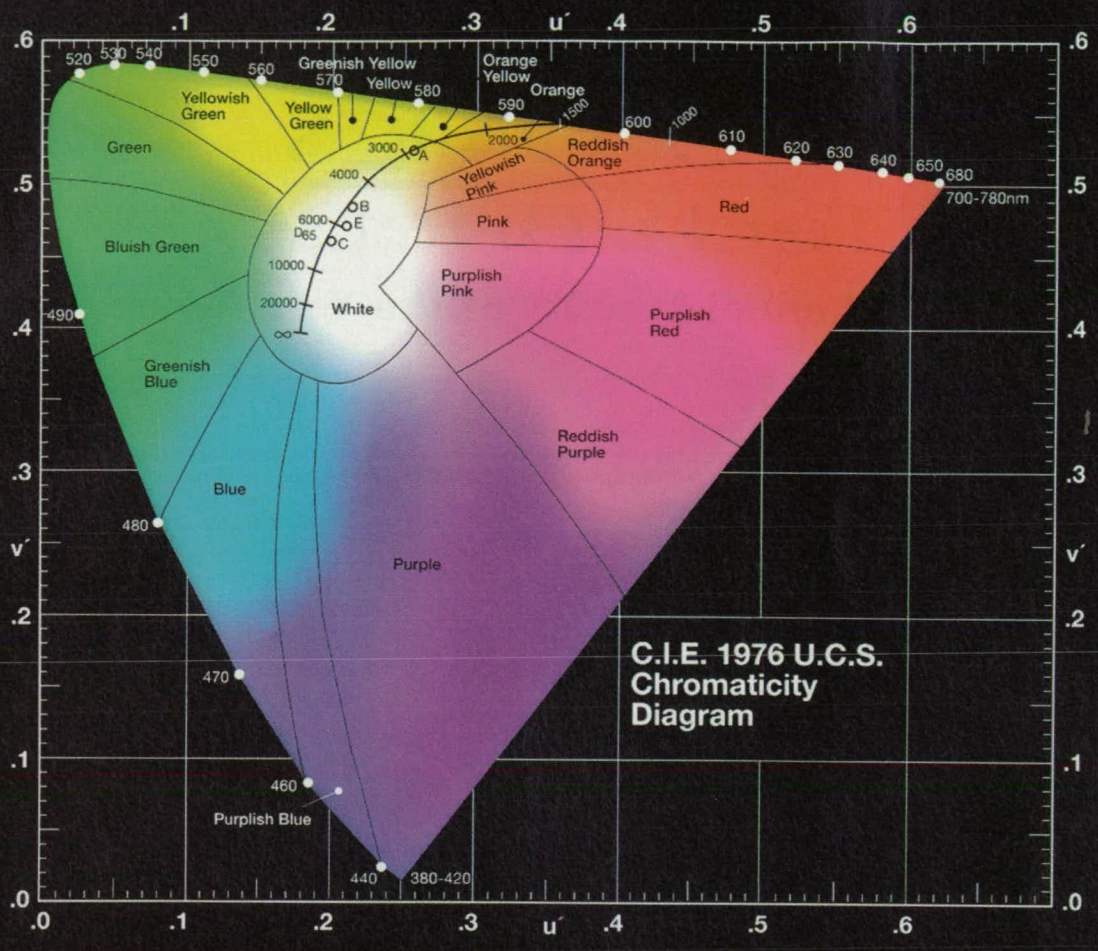


On the cover: Along with improved and higher-powered lasers comes the need for products that ensure the safety of those using them. Trinity Technologies, Minneapolis, MN, offers laser protective windows that allow visual access to laser application areas while providing optical protection for employees and observers. Made of acrylic, they come in a standard size of two by three feet, but may be custom cut. See New Products, page 23a.



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Cast Your Vote for

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Second Annual Product of the Year Award

Each issue of *Photonics Tech Briefs* in 1998 carried a Product of the Month—a photonics product the editors felt was of special interest and value to readers who work with lasers, optics, fiber optics, video and imaging equipment. This month *Photonics Tech Briefs* readers are invited to vote for the one product you deem the standout among those chosen as Products of the Month. The product garnering the most reader votes will be named Photonics Tech Briefs Product of the Year.

Please read the descriptions below of the Products of the Month, and choose the ONE you feel should receive the Product of the Year award. On the ballot below please indicate clearly your choice in the appropriate box, and fax or mail the completed ballot to reach the editors by January 30, 1999. The Product of the Year will be announced in a subsequent issue.

Digital Laser Marking System Kit

Synrad, Mukilteo, WA, introduces what it calls the first laser marking system kit based on all-digital technology. The company says that anyone can purchase the partially assembled, self-contained kit of components, perform some minor integration, and have a system operating on a marking production line in just a few hours. At the heart of the system is the Synrad DH Series sealed RF-excited carbon dioxide laser marking head, based on digital and fiber optic technology and capable of 125 W output. Synrad says that its high noise immunity makes possible accurate and crisp marking on a variety of materials. Designed for industrial use, the laser can be expected to perform at specification for 35,000 continuous hours, the company says.

Low-Noise High-Speed CCD Camera

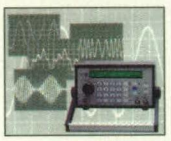
The AdaptIII™ CCD camera from PixelVision, Beaverton, OR, was designed for high-performance imaging at rates of up to 10,000 frames per second (fps). Featuring a back-illuminated CCD, it generates high frame rates through the use of multiple outputs and proprietary amplifier designs. Noise performance is as low as 3 electrons rms at 250 fps, the company says, and fewer than 12 electrons rms at 1250 fps. PixelVision uses 40 output amplifiers that are digitized, multiplexed, and sent over a serial fiber optic transmission link to the company's LynxPCI™ interface boards. AdaptIII is modular in design, and its electronics are housed in a rugged, hermetically sealed package.

Optical Linear Encoder

BEI Sensors & Systems Co.'s Encoder Systems Division, Sylmar, CA, introduces its LIE5 Series optical linear encoders, the first product to be developed under a new business alliance with Carl Zeiss Group. Called the most efficient microelectronic technology to result from an extensive research and development effort by the two companies, the LIE5 encoder is a reflective-read device that works in conjunction with a steel measuring scale. BEI says the head employs flip-chip-on-glass optics, which account for its small size as well as its ability to include built-in interpolation circuitry with resolutions as fine as 0.1 µm and output frequency up to 36 MHz. The head's dual scanning arrays allow for continued reading under contamination conditions that the company says would prove fatal to other linear encoders.

Goniometric Radiometer for Laser Diodes

Photon Inc., Santa Clara, CA, says its Model LD 8800 goniometric radiometer is specifically designed for measuring the radiation pattern emitted from a highly divergent source such as a laser diode or an LED. The company says the instrument, which precisely measures angular divergence and intensity distribution, is based on a proprietary patent-pending rapid scanning pinhole technique invented by Photon. This, the company asserts, makes possible measurements in a few seconds that previously could take hours. Single goniometric scans are done at 10 Hz and a full 3D characterization is completed in about one minute. Sampling resolution in the angular direction is 0.05° and in the azimuthal direction less than a degree.



20-MHz Benchtop Signal Generator

Berkeley Nucleonics Corp., San Rafael, CA, says the Model 625A SmartARB function, pulse, and arbitrary waveform generator was designed to provide more operating modes, more functions, and more measurement modes than any other unit in its price class. The arb clock is fully synthesized, unlike a clock generated by a DDS phase accumulator, which can result in phase jitter and missed points when the arbitrary waveform frequency is changed. The 625A's modes include standard sine, square, ramp, triangle, and random waveforms, but also AM, FM, PM, SSB, FSK, BPSK signal modulation, DTMF generate, DTMF detect, voltage and power measurement, and data and word generation.

Long Phase Mask

The LPM Series long phase mask from Lasiris Inc., St-Laurent, Quebec, Canada, combines the high accuracy achievable by two interfering laser beams, the company says, with the most reliable and repeatable phase-mask fabrication process ever designed. Within its 100-mm grating length, it eliminates the stitching error or phase error associated with E-beam mask technology, which Lasiris says makes it perfect for fabricating dispersion compensation fiber gratings. Long phase masks are available in constant period and linear chirp.

1998 *Photonics Tech Briefs* PRODUCT OF THE YEAR BALLOT

Indicate your choice by clearly marking the appropriate box. Fax or mail your completed ballot to Robert Clark, Senior Editor, *Photonics Tech Briefs*, 317 Madison Avenue, Suite 1900, New York, NY 10017, before January 31, 1999; Fax: (212) 986-7864.

- ❑ **February:** Synrad Digital Laser Marking System Kit
- ❑ **April:** PixelVision AdaptIII CCD Camera
- ❑ **June:** BEI Sensors & Systems LIE5 Series Optical Linear Encoder
- ❑ **August:** Photon Inc. Model LD 8800 Goniometric Radiometer
- ❑ **October:** Berkeley Nucleonics Model 625A SmartARB Arbitrary Waveform Generator
- ❑ **December:** Lasiris Long Phase Mask

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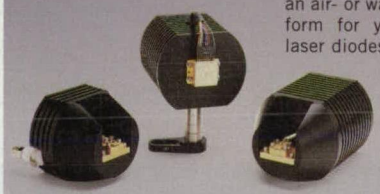

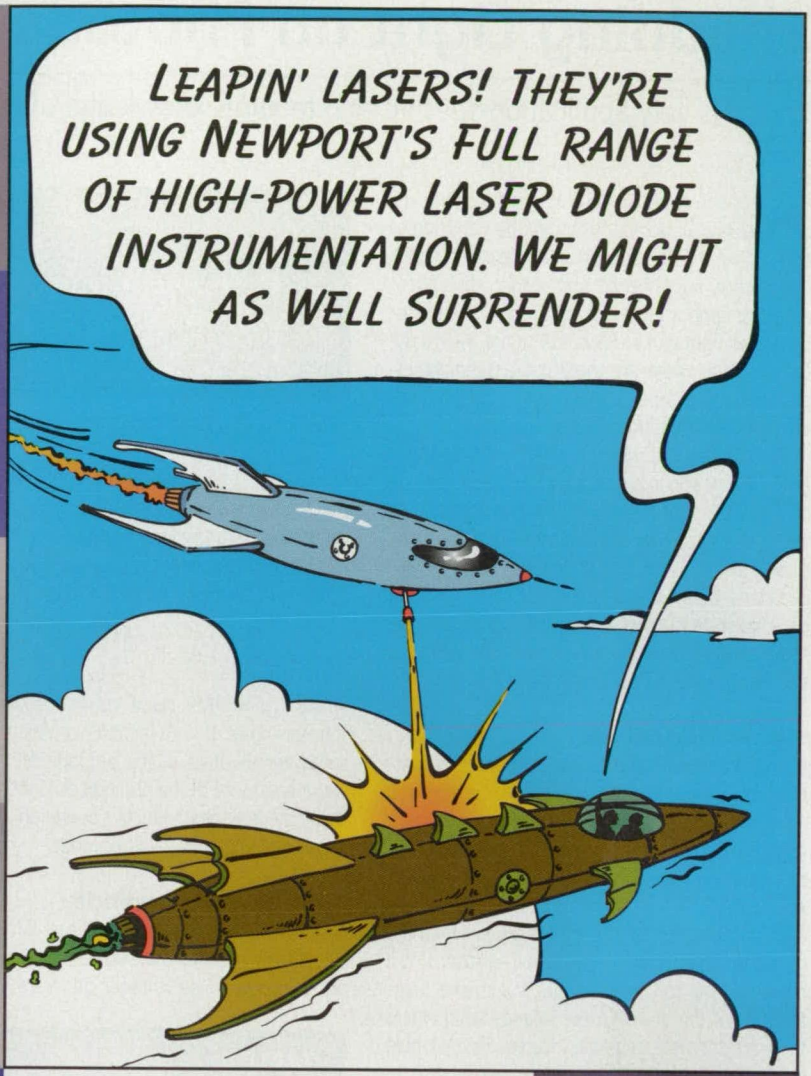

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Shedding Light on Photodetector Selection

Choice is very application-specific, and requires knowledge of noise factors and amplifier circuits.

A great number of medical, industrial, and analytical applications require the detection of light; some of these are chemiluminescence, bioluminescence, fluorescence, and atomic absorption. All of the applications require the use of a detector to convert light into an electrical signal, and to accomplish this there are three basic technologies: photomultiplier tubes (PMTs), avalanche photodiodes (APDs), and photodiodes.

The question of when to use or not to use a PMT, APD, or silicon photodiode is not a simple one to answer. A photodiode is suitable in applications with excess light. In applications with very weak signals, a PMT is the best choice. But there are applications where the choice is not clear. Focusing on solid-state options, this article will review detector characteristics and the criteria for selection, and finally amplifier performance.

Silicon Photodiode

A silicon photodiode is essentially a P-N junction consisting of a positively doped P region and a negatively doped N region. Between these two regions exists an area of neutral charge known as the depletion region. When light enters the device, electrons in the crystalline structure become excited. If the energy of the light is greater than the bandgap energy of the material, electrons will move into the conduction band. This creates holes throughout the device in the valence band where the electrons were originally located. Electron-hole pairs generated in the depletion region drift to their respective electrodes—N for electrons and P for holes, resulting in a positive charge buildup in the P layer and a negative charge buildup in the N layer. The amount of charge is directly proportional to the amount of light falling on the detector. If an external circuit is connected to the electrodes, current will flow in the circuit.

That is the photovoltaic method of operation. It is also possible to apply a reverse bias to the photodetector, creating the photoconductive mode. This has the effect of increasing the electric field strength between the electrodes and the depth of the depletion region. The advantages of this kind of operation are higher speed, lower capacitance, and better linearity. However, dark current is directly dependent on reverse bias voltage, and thus becomes larger with increasing bias voltage. Generally, PIN photodiodes and APDs are operated in this fashion.

The noise in a photodiode can take two forms. The first is the shot noise of the dark current, a small current produced by a reverse voltage even when the device is dark. It results from the statistical uncertainty in the arrival rate of photons. It is present in all signals and has the following form:

$$I_{dark} = \sqrt{2qi_{dark}B}$$

where i_{dark} = RMS noise current, q = electron charge, I_{dark} = photogenerated signal current, and B = frequency bandwidth of the detector-amplifier combination. The second noise source is the thermal noise of the shunt resistance, also known as Johnson noise, and it takes the form:

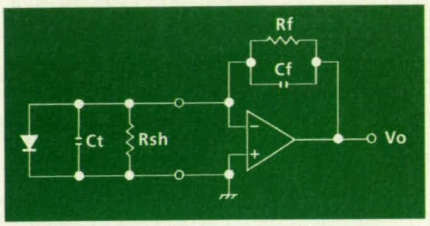

Figure 1. Transimpedance amplifier circuit.

$$I_{Rsh} = \sqrt{\frac{4kTB}{R_{sh}}}$$

where I_{Rsh} = RMS noise current resulting from Johnson noise, k = Boltzman's constant, T = absolute temperature of the photodiode, and R_{sh} = shunt resistance of the photodiode. Shot noise will dominate in photoconductive operation, and Johnson noise in the photovoltaic mode.

Avalanche Photodiode

The APD is a specialized silicon PIN photodiode designed to operate with high reverse voltages. These reverse voltages generate high electric fields at the P-N junction. Some of the electron-hole pairs passing through or generated in this field gain sufficient energy (greater than the bandgap energy) to create additional electron-hole pairs, a process known as impact ionization. If the newly created electron-hole pairs acquire enough energy, they also create new pairs. This effect, known as avalanche multiplication, is the mechanism by which APDs produce internal gain, an important attribute when the detector is combined with an amplifier.

Since the APD is always operated in the photoconductive mode, its noise takes the same form as the photodiode dark-current shot noise, with the addition of a few terms:

$$I_{APDdark} = \sqrt{2qi_{dark}M^2FB}$$

where M = detector internal gain and F = detector excess noise factor. Of the two additions, the gain simply amplifies the noise as it does the signal and has no net effect on the signal-to-noise ratio. The excess noise factor is noise added to the output signal by the multiplication process of the APD and is strongly dependent on wavelength as well as gain.

So far the only factor to play a role in detector selection has been noise equivalent power (NEP), the amount of light equivalent to the noise level of

TABLE 1:
Selected Detectors and Their Key Parameters

Parameters	S1337-33BR Photodiode	S2386-33BR Photodiode	S2384APD
Sensitivity (S)	0.6 A/W	0.6 A/W	30 A/W
Dark Current (i dark)	10 pA	100 fA	1 nA
Shunt Resistance (Rsh)	1 GW	50 GW	N/A
Terminal Capacitance (Ct)	65 pF	4300 pF	40 pF
Excess Noise Factor (F)	1	1	3.7
Gain (M)	1	1	60

TABLE 2:
Selected Detectors and Their Key Parameters

Parameters	S1337-33BR Photodiode	S2386-33BR Photodiode	S2384APD
I_{dark}	1.8e-14	1.7e-15	—
I_{apdark}	—	—	2.6e-12
I_{Rsh}	4e-14	5.7e-15	—
I_B	5.6e-15	5.6e-15	5.6e-15
I_f	4e-14	4e-14	4e-14
I_v	3.5e-15	2.3e-13	3.6e-17
I_{tot}	6e-14	2.3e-13	2.6e-12
NEP Detector + Amp	1e-13Wrms	3.8e-13Wrms	8.6e-14Wrms
NEP Detector	7e-14	9.9e-15	8.6e-14

Bandwidth = 100 Hz, feedback resistor = 1 GW, amplifier bias current = 1 pA, input noise voltage = 15 nV/Hz $^{1/2}$

Lasers

Instruments

Optics

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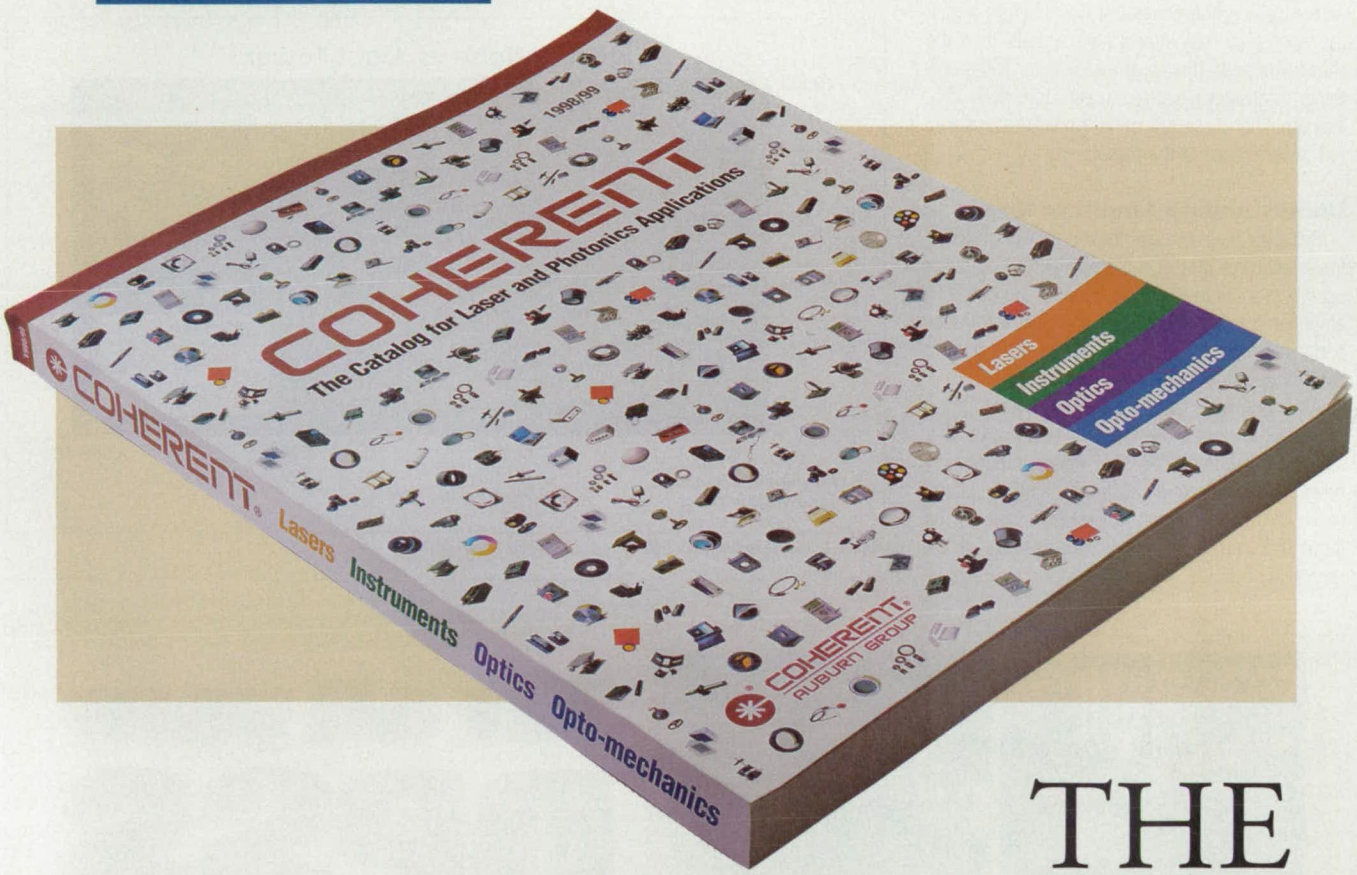

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a device, or, put another way, the light level required to obtain a signal-to-noise ratio of unity. Since the noise level is proportional to the square root of the frequency bandwidth, the NEP is measured at a bandwidth of 1 Hz and expressed in units of $W/Hz^{1/2}$. But as the light level increases, the NEP no longer plays a role in the signal-to-noise ratio. The shot noise of the signal tends to dominate the signal-to-noise ratio.

$$I_{signal} = \sqrt{2q\left(i_{signal} + i_{dark}\right)M^2FB}$$

where i_{signal} = photogenerated signal before gain. If the application has strong light signals, then the shot-noise performance of the detector is the only thing to consider, because the detector's dark noise and amplifier noise will be insignificant compared to the shot noise of the signal.

Understanding Amplifier Noise

Probably the most overlooked aspect of detector selection is that of the amplifier. The amplifier usually sets the lower noise floor for the detector-amplifier combination. Figure 1 shows a transimpedance amplifier, the configuration used here in the calculation of noise.

Amplifier noise can be broken down into three major components. The first two take the familiar form of the photodiode shot noise and Johnson noise. The third term arises from the input voltage noise of the amplifier. It is the shot noise of the input bias current and the Johnson noise of the feedback resistor. It is very strongly related to the frequency bandwidth.

The total detector-amplifier noise becomes:

$$I_{tot} = \sqrt{\left(i_{dark}\right)^2 + \left(i_{Rsh}\right)^2 + \left(i_b\right)^2 + \left(i_f\right)^2 + \left(i_v\right)^2}$$

It is now possible to calculate the NEP for a given detector and, based on these calculation, select the best detector for a particular application.

Referring to Table 1, the S1337 photodiode is designed for low capacitance, the S2387 for low dark current, and the APD to produce gain. The tables evaluate the noise performance of each device to facilitate the choice of detectors. Table 1 shows the specifications, selected with approximately the same active area size.

Table 2 sheds some light on detector selection. If it is chosen by the detector catalog's NEP alone, the total instrument performance has not been optimized. From the above information, the choice might seem to be the APD. But the APD requires a high-voltage power supply to bias it, is very temperature-sensitive, and generally costs more than a photodiode. So, in the above exam-

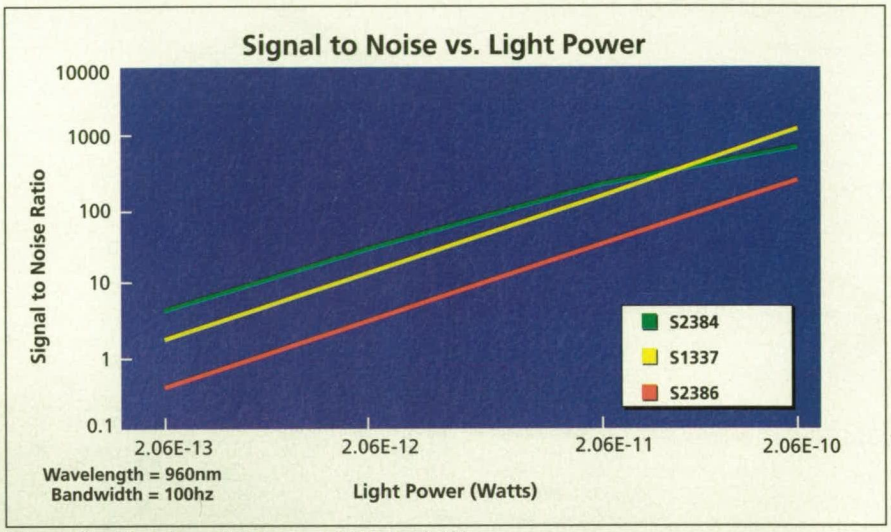

Figure 2. Signal-to-noise vs. light power at 100-Hz bandwidth.

ple, the S1337 would seem to be the best choice. Furthermore, when considering the detector's signal-to-noise performance at various light levels, it can be seen from Figure 2 that the photodiode's signal-to-noise ratio will be better than the APD when the amplifier noise is no longer a factor. This is because of the excess noise factor of the APD. Unless the application demands the lowest NEP possible, the photodiode would be the best choice under these conditions.

When is the APD a good detector selection? Based on the above equations, it is evident that the amplifier noise is strongly dependent on the frequency bandwidth. Figure 2 was calculated at 100 Hz. If the calculation were instead done at 1 MHz, the result would be much different, as shown by Figure 3. Of course, choosing a photodiode with lower capacitance would have closed the gap with the APD. However, the point is that the gain of the APD is necessary when the amplifier noise is large, as is the case with wide-frequency-bandwidth applications, or the light source is weak.

Choosing the correct detector is very application-specific, but here are some guidelines.

- Try to use the smallest active area possible. If the light source for the application is diffuse, this might not be practical; however, from the standpoint of noise, small diodes have lower capacitance and dark current, and are less expensive.
- In most applications, small capacitance will be more important than small dark current. Furthermore, the NEP in the catalogs does not take capacitance into account; therefore care should be exercised when comparing detectors by NEP.
- In small-frequency-bandwidth applications, photodiodes operated in a photovoltaic mode will generally outperform photoconductive devices. To reduce noise the detector's shunt resistance should be much greater than the feedback resistance.
- To reduce the contribution of Johnson noise, use as large a feedback resistor as possible in the first amplifier stage.
- In wide-frequency-bandwidth applications, PIN photodiodes operating in the photoconductive mode are preferred because of lower terminal capacitance. APDs with their internal gain perform very well in wideband applications as well. They should be considered when the light source is weak and the amplifier noise is large.

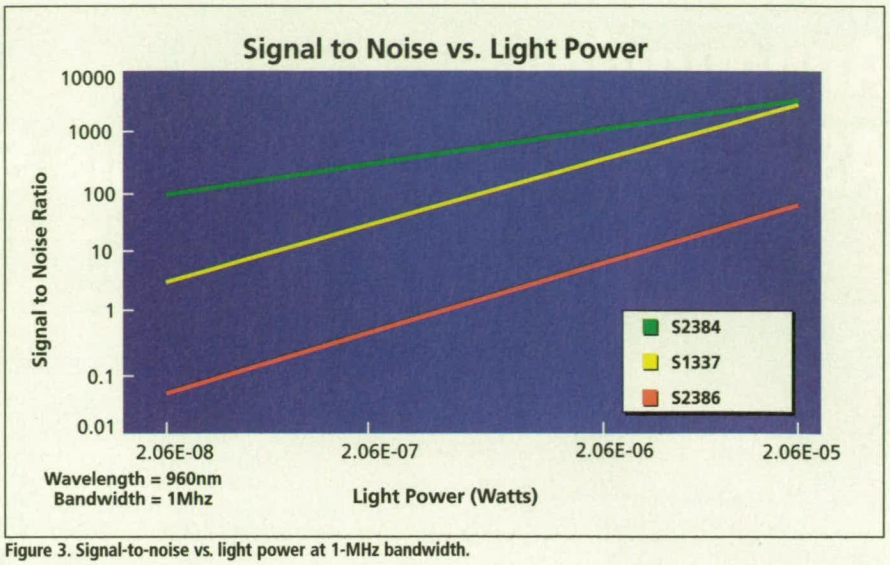

Figure 3. Signal-to-noise vs. light power at 1-MHz bandwidth.

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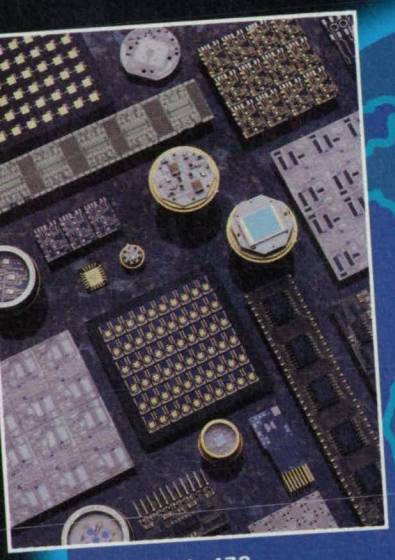

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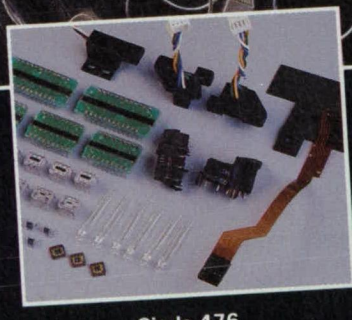

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Getting the Goods on Laser Beam Intensity

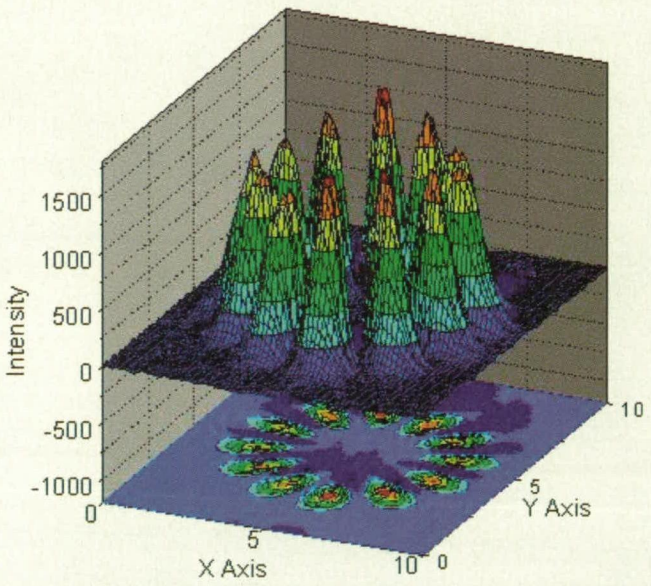
New software from Microcal makes possible 3D graphical views of the beam cross section.

At the National Institute of Optics (INO) in Florence, Italy, researchers Marco Ciofini and Riccardo Meucci and graduate student Antonino Labate, in collaboration with other INO staff members, have developed an instrument that combines pyroelectric detectors and a scanning mirror to measure intensity variations in the cross section of a carbon dioxide laser beam. Their measurements show unexpected patterns and fluctuations that should be taken into account by anyone designing laser equipment used for metal cutting, data storage, measurement, and other applications. Key to the success of their study was the use of a data analysis software package called Origin, from Microcal Software Inc. of Northampton, MA, that is capable of storing and graphically depicting the data generated by the measurements.

INO, a public research institution operated by the Italian Ministry of University, Scientific, and Technological Research, has three distinct research units. The quantum optics unit pursues that discipline, nonlinear dynamics and optics, and radio-frequency devices. The optoelectronics unit is responsible for noninvasive optical control, biomedical diagnosis systems, and spectrometry. Finally, the optical metrology unit handles Fourier optics and coherent techniques, optical testing, computer-aided optical design, and diagnosis of works of art.

To measure the uniformity and stability of CO_2 laser output, INO researchers developed a special instrument that uses a 256-pixel array of pyroelectric detectors positioned in a straight line. Pyroelectric detectors are based on the fact that ferroelectric materials such as lithium tantalate exhibit a large spontaneous electrical polarization below a temperature known as the Curie point. Incident radiation alters the temperature and changes the polarization. When this happens, the charges induced in the electrodes produce a voltage across the slice if the external impedance is high. The sensor only produces an electrical output signal when the level of incident radiation changes. The process is independent of the wavelength of the incident radiation; hence, pyroelectric sensors have a flat response over a very wide spectral range.

The team combined this detector with a scanning mirror that moves the beam in the vertical direction to provide y-axis measurement capability. This detector offers an advantage over more commonly used photodiodes and thermal detectors in that it is capable of accurately distinguishing the spatial features of the beam



▲ A 3D reconstruction, plus a contour map, of the intensity profile of a mid-infrared laser created with Origin 5.0. To measure the uniformity and stability of carbon dioxide laser output, INO researchers developed a special instrument that uses a 256-pixel array of pyroelectric detectors positioned in a straight line.

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Scientific and Engineering Award: To Iain Neil for the Optical Design: Rick Gelbard for the Mechanical Design: Eric Dubberke for the Engineering and Panavision International, L.P. for the development of the Primo 3:1 Zoom Lens. Presented March 2, 1996

PRIMO 3:1 ZOOM LENS ARRAY

"Perfection is our goal for every lens we make. In fact, it is so critical to our customers that every Panavision lens is individually calibrated by hand," says Iain Neil, Executive Vice President of Panavision. "To make perfect pictures, the lenses themselves must be perfect. This means strict control of all the aberrations and all the potential zoom and focus defects during the design process. I've found that CODE V's optimization

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intensity. The researchers scanned the beam across the detector at a frequency of 50 Hz, generating accurate spatial measurements of the beam's intensity. The temporal behavior can be monitored independently by a standard fast photodiode.

This experimental setup easily provides a large volume of data to be analyzed. A single two-minute scan generates 25,600 data points. Microcal's Origin gives users the possibility of handling virtually unlimited volumes of data. Under an easy-to-use interface, the program also provides powerful data analysis routines used by the researchers to detect spectral information in their data, including Fourier transforms that convert their time histories to the frequency domain. Additionally, the package includes graphical capabilities that make it possible to display their data using three-dimensional charts that graph beam intensity as the third dimension on top of an X-Y axis that represents the cross section of the beam.

Many of the charts, especially those generated by lasers with relatively short cavities and large mirror diameters, reveal complex and interesting patterns such as those shown in the illustration. The pattern corresponding to a mountain range with the peaks arrayed in a circular form is only one of the many arrangements seen by INO researchers. Viewing the precise intensity distribution helps users understand the modal interactions of the laser. The intensity distributions observed by the pyroelectric detectors are extremely useful in laser design, particularly in the development and validation of spatial filters that can be used to provide specific intensity distributions.

Ciofini, Meucci, and Labate have drawn several conclusions from their work. The first and most basic is that developers of laser equipment, particularly those with large beam diameters, need to consider carefully the uniformity and stability of the beam. For example, in a surface treatment application, the uneven distribution of energy across the laser's cross section could easily produce inconsistent properties in the material being treated. Once the distribution of beam intensity is known, various focusing methods can be used in an effort to improve consistency. In some cases, an uneven energy distribution may be intentionally produced in order to increase the degree to which the laser's energy is focused on a very small area.

For more information on Origin, contact Microcal Software, Inc., One Roundhouse Plaza, Northampton, MA 01060; (800) 969-7720, ext. 36; fax: (413) 585-0126.

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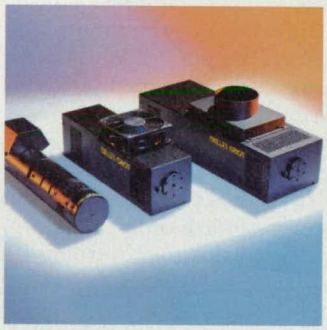

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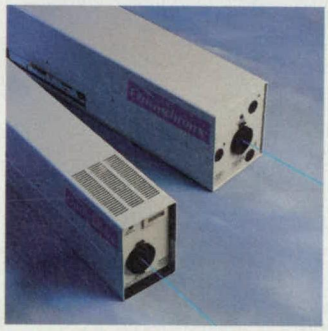

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Computer Code for Analysis of Stress in Silicon Wafers

MacWafer™ program runs on Macintosh, IBM PC, or PC clones.

Sandia National Laboratories, Livermore, California

The MacWafer™ code computes gravitational and thermal stresses in silicon wafers and uses these results to determine the maximum allowable temperature variation across a wafer, maximum processing temperatures, and maximum allowable heating and cooling rates. This information is of particular interest in the case of processing 300-mm wafers coupled with fast ramp technologies. The program runs interactively on Apple Macintosh, IBM PC, and PC clones, and workstation computers as well. Execution time is typically about 20 seconds on a Motorola 68040 processor operating at 33 MHz.

Gravitational stresses and displacements are first calculated based on the user's input of a wafer support geometry. This may consist of one or more continuous rings or up to 20 arbitrarily placed point supports. The maximum allowable processing temperature is then computed by comparing calculated gravitational stresses with the temperature-dependent strength of the wafer. One of the three published models of the strength may be selected. The difference between wafer strength and the gravitational stress is used to determine the allowable thermal stress and allowable temperature variation across the wafer. Finally, a model of radial heat transfer in a batch furnace is used to compute the maximum heating or cooling rate as a function of the allowable temperature difference and the user's inputs of wafer spacing and maximum available heater power.

Outputs to the screen include all stress components and vertical wafer displacements, as well as tables of maximum stresses and maximum heating and cooling rates as a function of temperature. All inputs and outputs may be directed to user-specified files for further processing or for display via user-supplied graphics software.

Gravitational stress and wafer displacements are computed by solving the fourth-order elliptic partial differential equation governing elastic deformation of thin plates. The particular solution for a specified support geometry is constructed by superposition of general Fourier-series solutions applicable to ring and point supports. A nonlinear equation solver is used to determine the fraction of the wafer weight carried on each support element, including cases in which the wafer may not contact all supports. Thermal stresses are also determined analytically by evaluating known integral solutions for the case of an axisymmetric temperature field that varies quadratically with distance from the wafer's center. For the special case of a batch furnace, the radial temperature variation across the wafer during heating and cooling is related to the ramp rate based on an analytical solution to the problem of radial heat transfer. This solution accounts for both conduction through the silicon and radiation between opposing wafer faces, as well as for direct radiant exchange between wafer surfaces and the furnace walls. The total stress is obtained by tensor addition of

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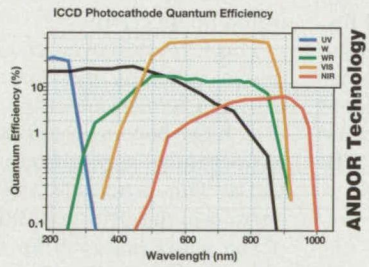

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local components of the thermal and gravitational stresses.

MacWafer™ is the only existing computer code that is specifically written to analyze stresses in silicon wafers. Both the user interface and solution procedures are highly specialized and optimized well beyond those available in general-purpose finite-element and finite-difference solid-mechanics codes. As a result, execution times for all MacWafer routines are short enough to permit enjoyable interactive use on personal computer platforms. In addition, the interactive interface is sufficiently self-explanatory that there is no need for a user's manual. All required code inputs are displayed on the screen, including initial default values that may be interactively altered by the user. Help, notice, or warning messages are displayed whenever input problems arise. The code is also unique in automatically performing many of the iterative trial-and-error searches required to yield the results most needed by equipment designers and process engineers. For example, the code directly computes maximum allowable temperatures and maximum heating and cooling rates, rather than simply indicating whether or not plastic deformation occurs for a given set of process conditions.

This software was developed by Bob Nilson and Stewart Griffith of **Sandia National Laboratories**, *Livermore, CA, under DOE contract no. DE-AC04-94AL8500. Information regarding licensing of the software can be obtained from Sandia's web page: http://www.ca.sandia.gov/macwafer/, or by contacting C.V. Subramanian , Manager of Licensing, at (510) 294-2311.*

Selective Metallization for High-Temperature Semiconductors

The process consists of three phases.

Cornell University, Ithaca, New York

Inventors at the Cornell Research Foundation have devised a method of selective metallization of high-temperature semiconductors to produce ohmic or rectifying contacts. The process consists of three phases: a lithographic step to define the areas of contact, preparation of the semiconductor surface, and deposition of the metallization via chemical vapor deposition.

The invention provides a method for forming electrical contacts on high-temperature wide-bandgap semiconductors such as diamond and silicon carbide. Because such semiconductors are not attacked by WF_6 or other CVD gases, the CVD metals or DVD refractory metal silicides normally will not seed on the surface in the areas exposed during the lithographic step. This problem is overcome by modifying the semiconductor surface in the exposed areas by using an ion beam to implant ions of a refractory metal. Depending on the materials used and the energy of the beam, either damaged surface regions or buried layers below the semiconductor surface will be produced. Buried layers will be exposed by a subsequent etching step. A CVD may now be performed to deposit metallization, which will make contact directly with the semiconductor at the sites of the damaged surface or buried layer.

The process has been successfully demonstrated on silicon dioxide. To elaborate, a surface which would not allow seeding of tungsten has been successfully modified by implantation to cause it to seed tungsten and allow the growth of layers thick enough for interconnects. Developmental effort is required to implement the patented concept with wide-bandgap semiconductors, but this result indicates that the effort would be successful.

This invention overcomes the difficulties in attaching metallization to wide-bandgap semiconductors of the kind that have become important in high-temperature applications, lasers, and LEDs. The process is self-aligned and permits high-purity depositions. The use of refractory materials for the metallization provides good resistance to electromigration and permits high process temperatures. The process can be applied to a variety of semiconductors, including silicon carbide, silicon nitride, boron nitride, and diamond.

This work was done by D.A. Lilienfeld, D. Thomas, P.S. Smith, G. Comeau, and R. Soave at **Cornell University**. *For more information call Robert F. Schleelein, Technology Marketing and Licensing Specialist, Cornell Research Foundation Inc., 20 Thornwood Drive, Suite 105, Ithaca, NY 14850; (607) 257-1081; fax (607) 257-1015; E-mail: rfs4@cornell.edu; http://www.research.cornell.edu/crf.*

Miniature, Tunable, Wide-Band-Pass Optical Filters

Short-cavity Fabry-Perot filters would offer wide tuning ranges.

NASA's Jet Propulsion Laboratory, Pasadena, California

A proposed miniature, electrically tunable, band-pass optical filter would have a Fabry-Perot configuration, but would be designed to trade the high spectral resolution (narrow-band pass) and small tuning range of a traditional Fabry-Perot filter for low spectral resolution (wide-band pass) and a wide tuning range. Filters like this are candidates to supplant two other types of optical filters used in remote-sensing spectrometers: namely, acousto-optical

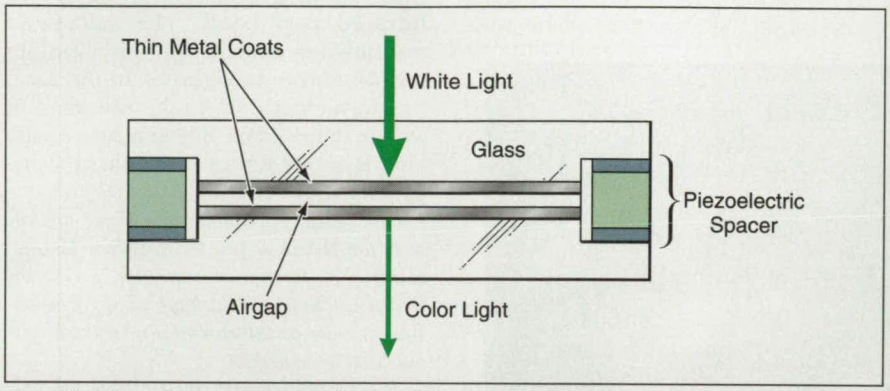

Figure 1. A **Short-Cavity Fabry-Perot Filter** would be tuned by adjusting the voltage applied to piezoelectric spacers.

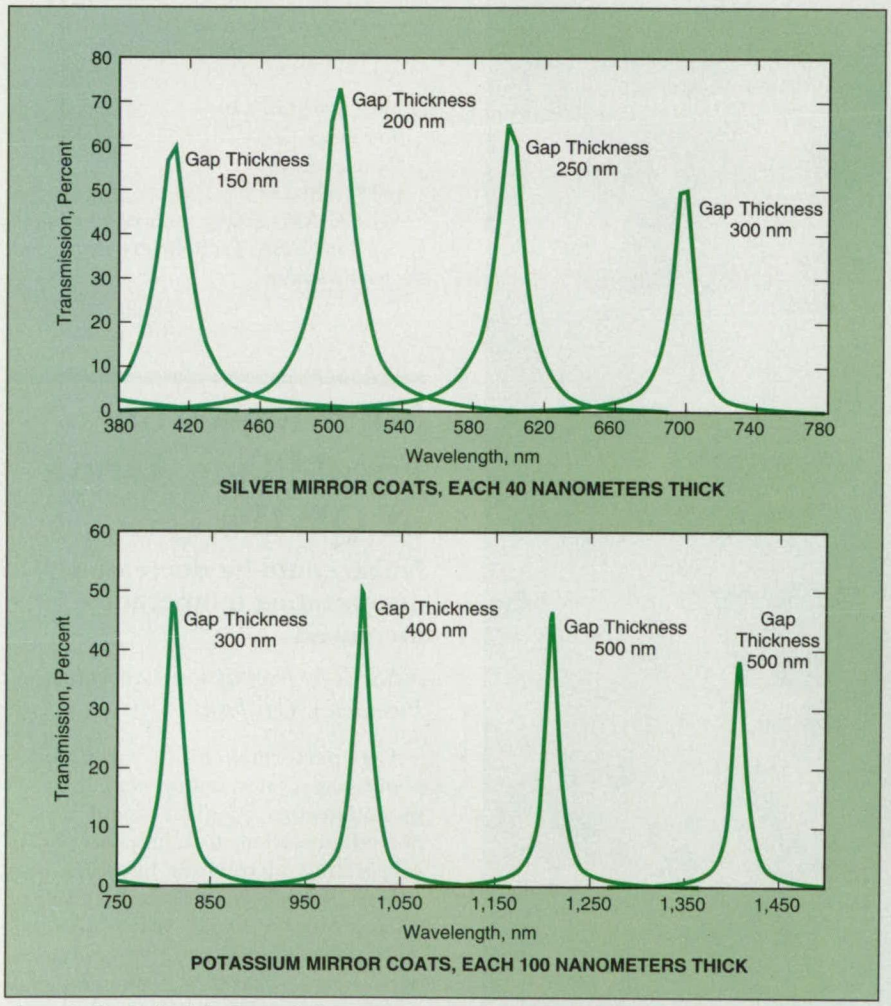

Figure 2. The **Peak of the Transmission Spectrum Would Shift** with a change in the gap thickness.

tunable filters (which are heavy and power-hungry) and liquid-crystal tunable filters (which exhibit low efficiency and work only in narrow temperature ranges).

A Fabry-Perot filter can be characterized as an interference filter and as a resonant optical cavity. It comprises a cavity bounded by partially reflective, low-absorption mirror coats on two flat, transparent plates. A traditional Fabry-Perot filter is a high-spectral-resolution (narrow-band-pass), narrow-tuning-range device constructed with low-absorption mirror coats and a cavity that is many wavelengths long. In the proposed filters, the traditional low-absorption mirror coats would be replaced by lossy metal coats only a few tens of nanometers thick, making the optical properties partly dependent on the choice of metal. In addition, the cavities would be shortened to less than one wavelength, increasing the tuning ranges for given small displacements; for example, as described below, if the distance between lossy mirror coats were made variable from 150 to 300 nm, then the tuning range would span the spectrum of visible light.

A typical proposed filter (see Figure 1) would include two glass plates with silver mirror coats 40 nm thick, separated by an airgap about half a wavelength thick. The gap thickness (cavity length) would be established by piezoelectric spacers. Thus, the filter could be tuned by applying a suitable voltage to the spacers. Figure 2 shows the calculated transmission spectra for various cavity lengths; the wavelength of peak transmission would range from 410 nm at a cavity length of 150 nm to 700 nm at a cavity length of 300 nm.

In another example, the mirror coats would be made of potassium 100 nm thick, making it possible to obtain an infrared pass band. The calculated transmission spectra for this example are also shown in Figure 2. In this case, the wavelength of peak transmission would range from 800 nm at a cavity length of 300 nm to 1,400 nm at a cavity length of 600 nm.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Microlenses on Focal-Plane Arrays of QWIPs

Noise could be decreased or operating temperature increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

The performances of large focal-plane arrays of quantum-well infrared photodetectors (QWIPs) would be improved, according to a proposal, by incorporating microlenses. In comparison with a similar QWIP array that lacked microlenses, a QWIP array with microlenses could be made to exhibit less dark current [and thus a greater signal-to-noise ratio (SNR)] at a given temper-

ature. Alternatively, the QWIP array with microlenses could be made to exhibit a given SNR at a higher temperature; this would be advantageous in that it would open up the possibility of operating QWIPs in infrared cameras at higher temperatures, reducing the cost of cooling the QWIPs to obtain adequate SNRs.

It would be advantageous to reduce dark current for two reasons:

1. The noise current of a photodetector is proportional to the square root of its dark current.

2. Along with signal current, dark current contributes to filling of the charge-storage wells of a readout multiplexer. Because of this and because the amount of charge that can be stored is finite, the available charge-integration time decreases with increasing dark current. As the charge-integration time decreases, the SNR decreases.

Assuming that the QWIPs in a given array were designed to operate with back-side illumination, the microlenses would be formed on the back side (the substrate side) of the array (see figure). There would be one microlens for each pixel. The basic function of the microlenses would be to concentrate incident infrared radiation (or preserve optical area) into a fraction of the area of each pixel. Concomitantly, the active device area in each pixel would be reduced to encompass only the reduced illuminated area plus (if desired) an appropriate margin. Inasmuch as the dark current of a QWIP is proportional to its area, the dark current would be reduced accordingly.

Suppose, for example, that a QWIP array had a 50-μm pixel pitch with active pixel areas of 45 by 45 μm. Microlenses could be used to concentrate light into 15-by-15-μm active pixel areas. If the active pixel areas were reduced to 15 by 15 μm, then the dark current at a given temperature would be reduced to 1/9 of its previous value, and therefore, the noise current at that temperature would be reduced to 1/3 of its previous value.

This work was done by Sarath Gunapala, Sumith Bandara, and Fred Pool of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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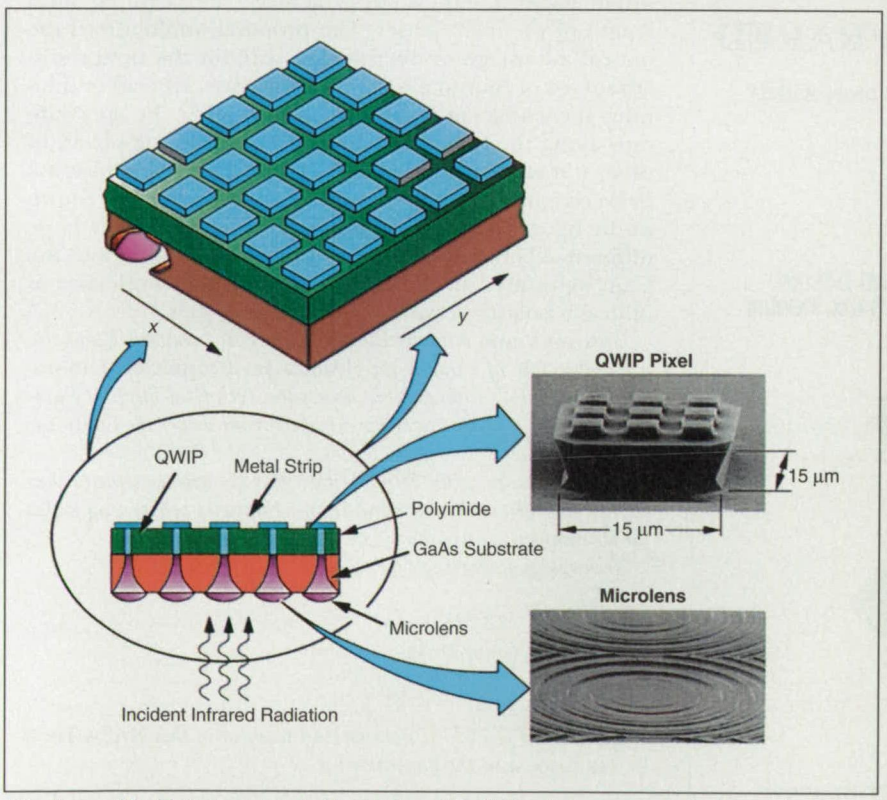

Microlenses Would Concentrate Incident Infrared Radiation (or preserve optical area) into areas smaller than those defined by the pixel pitch. The areas of the QWIPs could be reduced concomitantly to reduce dark current.

Trenches Would Reduce Cross-Talk Among Microlensed QWIPs

Less scattered light would impinge on neighboring pixels.

NASA's Jet Propulsion Laboratory, Pasadena, California

Cross-talk in integrated-circuit focal-plane arrays of quantum-well photodetectors (QWIPs) equipped with microlenses would be reduced, according to a proposal, by etching deep trenches into the substrates of these devices. The proposal applies, more specifically, to GaAs-based, back-side-illuminated QWIP arrays with microlenses — devices like those described in the preceding article.

The cross-talk problem in such a device without trenches would arise as follows: The microlenses would be formed by patterning the back side of the substrate, as described in the preceding article. The lenses would focus the incident infrared light into and through sub-pixel-size active device (QWIP) areas. Most of the focused light would not be absorbed by the QWIPs, due to lower quantum efficiency, and would, instead, be scattered from patterned reflective surfaces on the front side. A significant portion of the light scattered in each pixel would travel through the unthinned substrate to neighboring pixels, where some of it would be absorbed, thereby giving rise to cross-talk. The cross-talk-reduction problem would thus become one of preventing the scattered infrared light from traveling through the substrate to neighboring pixels.

The problem could not be solved by thinning the entire substrate to the membrane level because such thinning would make it impossible to achieve the required focal length of the microlenses. The proposal would afford the optical advantage of microlenses, without the optical disadvantage of thinning the entire substrate. Instead of thinning the entire substrate, one would etch the substrate only along the boundaries between neighboring pixels; in other words, one would etch deep trenches in the substrate between microlens/pixel units. Such trenches are shown in the figure of the preceding article. Because of the large difference between the indices of refraction of air and the GaAs substrate, the trenches would be highly effective as optically isolating cavities to reduce cross-talk.

This work was done by Sarath Gunapala, Sumith Bandara, and John Liu of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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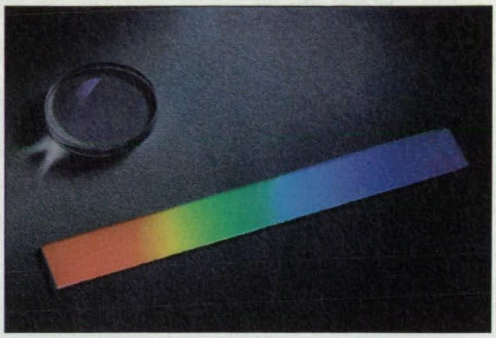
Refer to NPO-20311, volume and number of this NASA Tech Briefs *issue, and the page number.*

NEW PRODUCTS

PRODUCT OF THE MONTH



Long Phase Mask

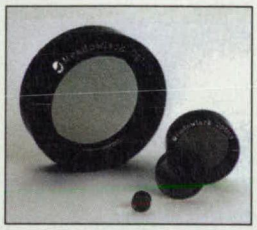
The LPM Series long phase mask from Lasiris Inc., St-Laurent, Quebec, Canada, combines the high accuracy achievable by two interfering laser beams, the company says, with the most reliable and repeatable phase-mask fabrication process ever designed. Within its 100-mm grating length, it eliminates the stitching error or phase error associated with E-beam mask technology, which Lasiris says makes it perfect for fabricating dispersion compensation fiber gratings. Long phase masks are available in constant period and linear chirp.

For More Information Circle No. 800

Laser Protective Observation Windows

Trinity Technologies, Minneapolis, MN, offers protective windows for laser observation areas, viewing boxes, and equipment cabinets. They allow visual access to laser application areas while providing eye protection for employees and observers. They are sold in a standard size of 24 × 36 inches, but may be custom cut to larger or smaller sizes. Made from acrylic, they are available for lasers ranging from UV, carbon dioxide, and excimer to Nd:YAG, near-visible, ruby and near-infrared.

For More Information Circle No. 802



Dichroic Linear Polarizers

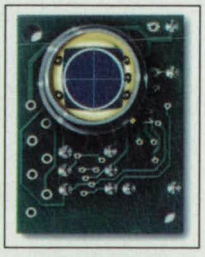
The dichroic linear polarizer from Meadowlark Optics, Frederick, CO, allows transmission of one polarization state by absorbing the unwanted state. Meadowlark says these compact and inexpensive polarizers are suitable for applications with low flux densities, large clear apertures, or wide field-of-view requirements. Among their advantages, according to the company, are a high extinction ratio and low transmitted wavefront distortion. They are available in the visible spectral region and portions of the ultraviolet and near-infrared.

For More Information Circle No. 803

Freezing-Point Blackbody System

Electro Optical Industries (EOI), Santa Barbara, CA, introduces the Multi-Point Primary Standard Blackbody (MPPSB) system that can be used to precisely calibrate radiometers, pyrometers, and other noncontact thermometers and thermal imagers. The MPPSB provides blackbody radiation at the International Temperature Scale (ITS-90) freezing-point temperature of indium, tin, zinc, aluminum, silver, gold, and copper. The use of interchangeable melt-material crucibles provides the option of multiple freezing-point calibration in a single system. EOI says the system provides calibration in 30-60 minutes.

For More Information Circle No. 805



Silicon Quadrant Photodiode

Centro Vision Inc., Newbury Park, CA, releases the QD50-0-SD, which uses a quadrant silicon photodiode with a total active diameter of 7.98 mm and total active area of 50 mm squared. The width of the quadrant separator is 0.2 mm; smaller separation is available. Each quadrant is connected to a transimpedance amplifier with a gain of 10,000 ohms; higher gain can be provided on request. Centro Vision says the circuit outputs make the circuit/photodiode combination ideal for light-beam nulling and position sensing applications.

For More Information Circle No. 809

Chip-on-Glass LCD Displays

New from Seiko Instruments USA, Torrance, CA, is what the company says is the first off-the-shelf LCD display developed using chip-on-glass technology. Based on a patented gold-plating technology, the Seiko Instruments Vitrium G8 is a 240-×-160 graphic chip-on-glass display with an overall thickness of less than 2 mm, incorporating the slim-chip LCD driver circuits onto the surface of the glass. Viewing area is 60.6 × 51.4 mm and dot pitch is 0.24 mm. Operating temperature range is -10°C - 60°C. Power supply requirement is 3 VDC, making it suitable for battery-operated devices. It uses a single flexible plastic cable that plugs into a zero-insertion-force connector. Price is $52 in quantities of 1000.

For More Information Circle No. 801

Multimode Return Loss Meters

The 680MRL series of multimode return loss meters from RIFOCS Corp., Camarillo, CA, use a train of light pulses to measure back-reflections in fiber optic systems. RIFOCS says that the instruments, designed for use with other RIFOCS 600 series modular rack-mount components, are the first in the industry to use optical reflection discrimination to measure return loss in multimode fibers. Unlike OTDRs, according to the company, these instruments can locate and accurately measure discrete reflections in cables as short as two meters long. They are available for testing 50/125-µm, 62.5/125-µm, and 100/140-µm fibers.

For More Information Circle No. 804

30/40-W Carbon Dioxide Lasers

The Laser Division of Universal Laser Systems, Scottsdale, AZ, introduces a family of RF-driven sealed-off 30- and 40-watt carbon dioxide lasers for OEM applications. The company notes that the family incorporates Universal's newly patented slab non-waveguide technology. The lasers can be equipped with optional straight or right-angle beam paths and an integrated red diode laser pointer. Universal says advantages include integrated air-cooling, dispensing with external fans or water cooling, and a compact design that allows simplified integration. The company will provide customization for specific applications.

For More Information Circle No. 808

DC-Regulated Fiber Optic Light Source

Illumination Technologies Inc., East Syracuse, NY, offers the 2900 DC-regulated fiber optic light source, which the company calls a true auto-switching supply that lets the user operate anywhere without flipping switches or changing fuse blocks. The company says that the robust yet economical DC regulation scheme provides the stability necessary for all applications that utilize video cameras or vision systems, and at a cost lower than AC sources. The 2900 is CE certified, and UL/CSA certification is pending.

For More Information Circle No 810

PHOTONICS Tech Briefs LITERATURE

EXFO PRODUCT OVERVIEW 1998-1999

The new *Product Overview 1998-1999* provides a quick look at what EXFO has to offer in fiber-optic test and measurement technology. It features effective new products for DWDM testing, such as wavelength meters, erbium-doped fiber amplifiers, and tunable lasers. Find out about our fast power meters and high-linearity OTDRs. Contact us today to receive your free copy. Fax: (418) 683-2170; phone: 1-800-663-3936 or (418) 683-0211; E-mail: info@exfo.com.

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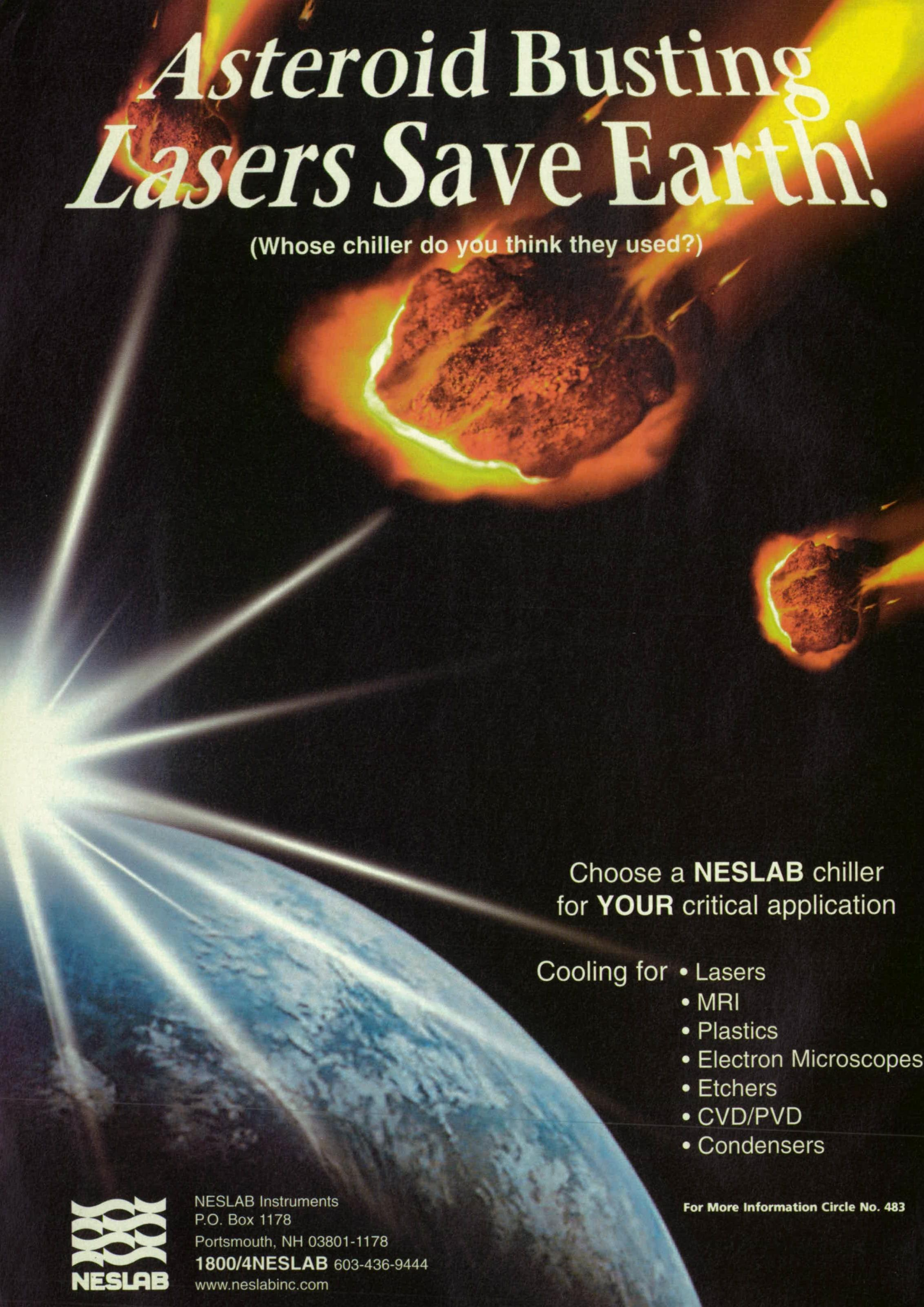
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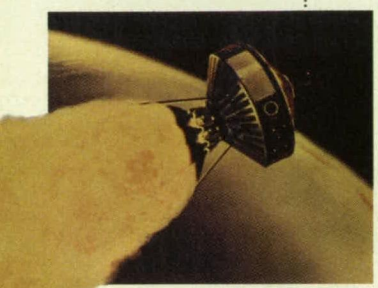
NASA's Technology Milestones: A Timeline

Fortieth Anniversary

In its first 40 years, NASA pioneered some of the most important technologies of the last four decades.

1950s

October 1, 1958: The National Aeronautics and Space Administration (NASA) officially begins operations.

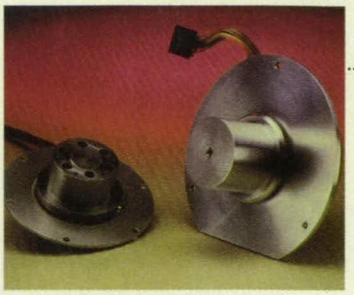


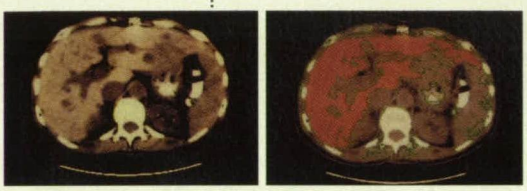
October 11, 1958: NASA launches its first spacecraft, *Pioneer 1*, which carries a TV scanner to photograph the lunar surface. Although *Pioneer 1* failed to reach the Moon, it attained a record altitude of 70,700 miles.

March 10, 1959: NASA begins testing the rocket-powered X-15, a missile-shaped aircraft capable of flying beyond Earth's atmosphere at Mach 6.

1959: NASA enlists the Pillsbury Company to help prepare wholesome "space foods." Pillsbury develops the Hazard Analysis Critical Control Point (HACCP) system to ensure the safety of all food consumed in space. HACCP later finds widespread use in the preparation of food for Earth-bound consumers.

1969: Ferrofluidics Corp. of Nashua, NH is formed by two scientists who licensed NASA technology in ferrofluids, a class of fluids possessing magnetic properties. Ferrofluids become widely used in film bearings, disk drives, robotics, lasers, rotary shaft seals, and dozens of other applications.





1960s: Digital signal processing (DSP) is pioneered at NASA's Jet Propulsion Lab to computer-enhance pictures of the Moon. DSP later is employed in advanced body imaging techniques such as computer-aided tomography (CATscan).

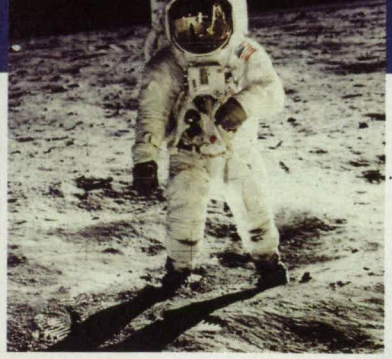
February 20, 1962: Astronaut John Glenn makes the first U.S. manned orbital flight. *Friendship 7* takes Glenn around the Earth three times during the five-hour trip.

1960s

April 12, 1960: NASA launches ECHO I — the first passive communications satellite, which reflects a radio message from President Eisenhower across the U.S., demonstrating the feasibility of global satellite communications.

1960s: NASA's development of ECHO's Mylar skin helps to build metallization into a flourishing industry. Metallized film subsequently is used in nearly all NASA spacecraft. Other metallized materials are used in outdoor clothing, food packaging, wall coverings, and reflective blankets.

May 5, 1961: NASA initiates U.S. manned space flight 23 days after Soviet cosmonaut Yuri Gagarin becomes the first human to orbit the Earth. Mercury astronaut Alan B. Shepard makes a 14.8-minute suborbital flight aboard the *Freedom 7* capsule.



July 20, 1969: *Apollo 11* astronauts Neil Armstrong and Edwin E. (Buzz) Aldrin become the first humans to walk on the Moon.

March 3, 1972: *Pioneer 10* leaves Earth, becoming the first human artifact to leave our solar system. *Pioneer 11* launches the following year. These automated probes send back photos and data from Jupiter and Saturn.

1970s

1974: Urban firefighters begin testing a new breathing apparatus based on life-support technology used by Apollo astronauts. The NASA-based system, lighter and less cumbersome than older equipment, is later adopted by fire departments across the U.S.

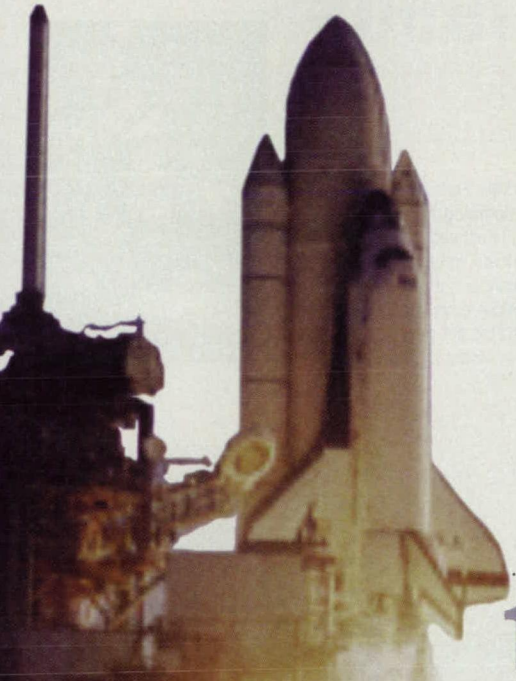
1973: The Skylab project is NASA's first effort to establish a space station. The orbiting laboratory holds three crew members along with the science instruments, a telescope, and a furnace for materials research.

1975: The Viking program lands two spacecraft on Mars and sends two others into orbit around the Red Planet. Viking landers take photos and sample the Martian soil and atmosphere.

1983: A shuttle mission marks the debut of the SPOC (Shuttle Portable Onboard Computer), a navigation monitoring computer. The SPOC is an adaptation of the GRiD compass — the first laptop computer — from GRiD Systems Corp., Fremont, CA.

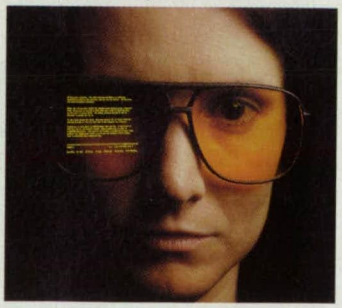
Timeline continues on next page.

1980s: Dr. Michael Vannier, a radiologist and former NASA engineer, begins applying Landsat satellite image-enhancement techniques to medical imagery. Incorporating this NASA-developed technology leads to the development of magnetic resonance imaging (MRI).



1980s

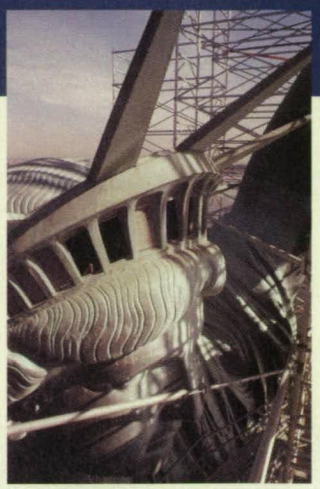
1980s: The Suntiger PST™ sunglass lenses are introduced. They block 99% of potentially harmful blue, violet, and ultraviolet wavelengths. The sunglasses are developed by NASA engineers who applied NASA techniques created to develop welding curtain dye formulas.



1982: Using software technology developed for NASA's Mars fly-by spacecraft, Research Systems of Boulder, CO, introduces IDL (Interactive Data Language) software. IDL allows scientists to investigate data directly, without writing a custom program.

April 12, 1981: NASA launches the Space Shuttle *Columbia*, beginning a new era of reusable spacecraft. *Columbia* is the first shuttle, the main component of NASA's new Space Transportation System (STS). The shuttle is an airplane-like spacecraft that makes a runway landing on return from orbit.

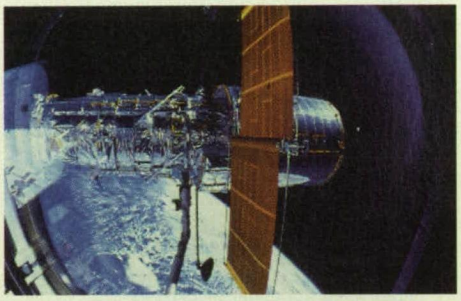
Timeline continued from previous page.



1984: IC 531 coating from Shane Associates, Wynnewood, PA, is chosen by the National Park Service for application on the Statue of Liberty to protect it from corrosion. The coating was developed by researchers at NASA's Goddard Space Flight Center.

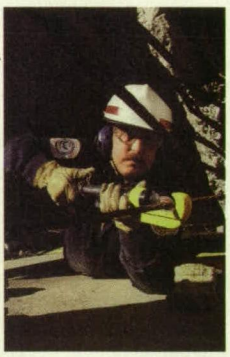
1984: Microspheres become the first commercial products manufactured in space. Made during Space Shuttle flights, the tiny plastic beads are perfect in shape, and are used as reference standards for accurate calibration of research and industrial instruments.

1989: The Siemens-Pacesetter's Synchrony Implantable Pacemaker System received FDA approval. Using NASA-developed bi-directional telemetry, the system allows doctors to communicate with the pacemaker after it is implanted in the body.



April 15, 1990: The crew of the Space Shuttle *Discovery* deploys the Hubble Space Telescope (HST). Because of HST's location above Earth's atmosphere, its instruments can produce high-resolution images of distant astronomical objects.

1990s



1995: Following the Oklahoma City bombing, rescue workers use the Lifeshear cutting tool to help extricate victims from the rubble. Lifeshear's power unit, based on NASA-developed pyrotechnics, generates hot gases that drive the blade through its target.

February 28, 1995: The largest airport built in the past 20 years opens. Denver International Airport uses as its prime air traffic management tool CTAS (Center-TRACON Automation System), a set of tools developed by a team at NASA's Ames Research Center. It later would be in daily use at the Dallas/Ft. Worth International Airport.

October 10, 1996: President Clinton announces the Next Generation Internet (NGI) Initiative, which should enable the Internet to run thousands of times faster by the year 2002. NASA's Research and Education Network (NREN) is designated as the project's lead organization.

July 4, 1997: The Mars Pathfinder lands in Ares Valles and deploys the Sojourner rover to inspect the Martian surface. Pathfinder relays to Earth the first-ever high-resolution color pictures of Mars.

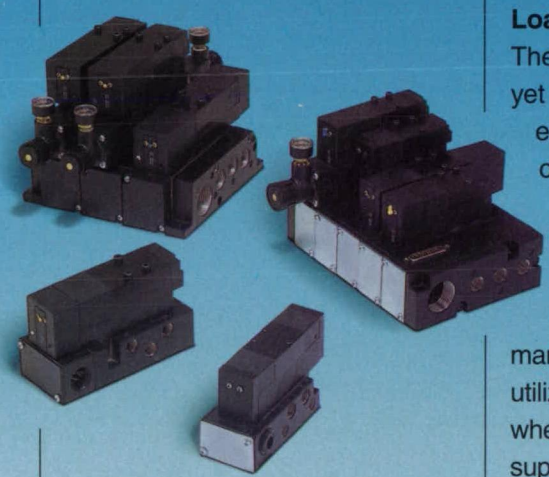
1996: Thermal Protection System (TPS) materials are incorporated into NASCAR race cars to protect drivers from intense engine heat. The materials originally were developed to insulate NASA's Space Shuttles from 3000°F re-entry temperatures.

November 20, 1998: The Zarya Control Module — the first element of the International Space Station — is scheduled to launch from the Baikonur Cosmodrome in Kazakhstan.

Computers Plug-and-Play . . . Parker's "F" Series Valves Plug-and-Work!

Parker's "F" family of plug-in subbase or manifold mounted valves are available in solenoid and air pilot operators in 2-position and all 3-position configurations. The F3 and F5, offer a .7 and 1.5 Cv respectively, with port sizes from 1/8" to 3/8".

The hallmark of the "F" family is Parker's ***WCS*** (***W**ear **C**ompensation **S**ystem*). ***WCS*** provides a method of operating valves in non-lube and/or contaminated plant air environments. By design, air pressure is directed under the spool seals, forcing them outward to seal against the valve bore. Pressurized seals compensate for wear and greatly extend the life of the valve.



Loaded with Features

The "F" family is compact in size, yet big on features. It comes equipped with a full compliment of sandwich flow controls and regulators. A pressure select regulator is available which saves on plumbing by integrating functions in one manifold. The "F" series valves utilize a low, 1.8 Watt solenoid pilot where LED's and surge suppression are standard.

Plug and Work Manifolds

Close attention has been paid to the connectivity of the "F" family. Interconnect circuit boards are available in manifolds, which plug into each other when bases are assembled. These circuit boards auto-address the solenoids, eliminating all "Spaghetti" manifold wiring, and terminate into a 25 pin Sub-D connector in the end plate. Connectivity is optimized by marrying the "F" family with Parker Serial Addressable Modules (SAM), available in a variety of Protocols.

For additional information or to locate your nearest distributor, call 1-800-498-7504. Visit us on the Web @ www.parker.com/pneumatic

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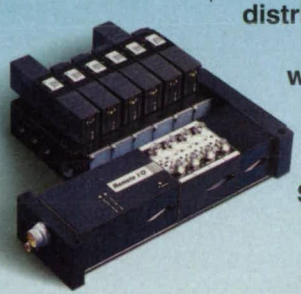

Serial Addressable Module
I/O in Several Protocols

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Each month in *NASA Tech Briefs* we highlight a Product of the Month — a new product with exceptional technical merit and practical value to our more than 200,000 engineering and management readers.

This month, you are invited to vote for the one product among those highlighted throughout 1998 that you feel was the most significant new product introduced for the engineering community this year. The product receiving the most votes will be named *NASA Tech Briefs* 1998 Readers' Choice Gold Medal Winner for Product of the Year. The products with the second and third highest number of votes will be awarded, respectively, the Silver and Bronze awards.

Last year's winner of the Gold Medal honor was CADKEY® 97 mechanical CAD software from Baystate Technologies of Marlborough, MA.

On the facing page are descriptions of each of the Products of the Month. Choose the one product you feel should receive Product of the Year honors, and cast your vote in one of the following ways:

- Visit the *NASA Tech Briefs* web site at **www.nasatech.com** and indicate your choice on the Product of the Year ballot;
- Complete the ballot below and fax it to the Editor at: 212-986-7864; or
- Mail the ballot to: Product of the Year, *NASA Tech Briefs*, 317 Madison Ave., New York, NY 10017.

Only one vote per person will be counted. Your completed ballot must be received by January 19, 1999.

The Readers' Choice Award winners will be announced on the *NASA Tech Briefs* web site, and in the March 1999 issue.

1998 *NASA Tech Briefs* Readers' Choice Product of the Year Ballot

Name: _____

Company: _____

Address: _____

City: _____

State: _____ Zip: _____

Phone: _____ Fax: _____

E-mail: _____

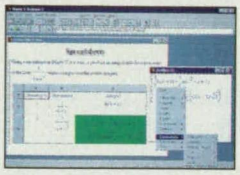
Check only one box

- ❑ **January:** IOtech – Personal Daq™ PC-based data acquisition systems
- ❑ **February:** National Instruments – LabVIEW Version 5.0 graphical instrumentation software
- ❑ **March:** Waterloo Maple – Release 5 Maple V technical computing software
- ❑ **April:** InPart – DesignSuite™ Internet-based 3D CAD model library
- ❑ **May:** DuPont Krytox Performance Lubricants – Krytox® XP lubricants
- ❑ **June:** Raytek Corp. – Thermalert® GP infrared temperature monitoring system
- ❑ **July:** Hyde Park Electronics – Superprox® Model SM607 ultrasonic proximity sensors
- ❑ **August:** Algor, Inc. – Release 12 FEA-based mechanical engineering software
- ❑ **September:** Omron Electronics – F30 miniature machine vision system
- ❑ **October:** Haptic Technologies – PenCAT/Pro™ 3D pen with force-feedback
- ❑ **November:** SPSS–SigmaPlot 5.0 scientific graphing software
- ❑ **December:** Inova Computers – ICP-K233 CompactPCI single-board computers

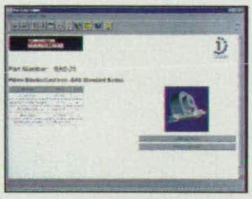
Product of the Year Nominees

IOtech, Cleveland, OH, offers Personal Daq™, the first full-featured PC-based data acquisition systems to fully utilize the Universal Serial Bus (USB), providing a single-cable connection to a PC with no battery or power cables required. The Personal Daq/55™ data acquisition system offers 22-bit A/D resolution, 10 single-ended or 5 differential analog or thermocouple input channels, and 16 programmable ranges. The Personal Daq/56 offers twice as many input channels and digital I/O lines.

Version 5.0 of LabVIEW graphical instrumentation software from National Instruments, Austin, TX, features an Instrument Wizard that allows users to create programs for instrument control with GPIB, VXI, and RS-232 instruments. The software also provides tools for system developers to create distributed applications, whereby various sections of code can execute on different machines across a network.



Waterloo Maple, Waterloo, ON, Canada, offers Release 5 of Maple V technical computing software that allows users to learn one interface but interact with a large number of commercially available packages. New features include a spreadsheet similar to Excel® that enables creation of a spreadsheet within a Maple V worksheet and a MATLAB link that enables access to the numerical processing power of MATLAB from within the Maple V environment.



InPart, Saratoga, CA, offers DesignSuite®, an Internet-based 3D CAD library for mechanical engineers and designers that contains 3D models and detailed technical specs of more than 100,000 mechanical components from leading U.S. suppliers. Once located, the 3D model can be viewed and downloaded directly to the user's 3D CAD system. Supported CAD formats include Pro/ENGINEER, STEP, IGES, and 2D DXF.

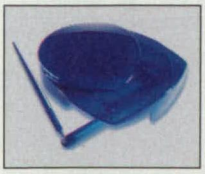
Krytox® XP lubricants from DuPont Krytox® Performance Lubricants, Wilmington, DE, include a soluble additive that enhances the performance properties of Krytox® PFPE greases and oils. The XP lubricants are formed with synthetic perfluoropolyether fluids, soluble additives, and polytetrafluoroethylene. Used in automotive, chemical processing, semiconductor, and aerospace applications, the lubricants are available in three viscosity grades of oils and greases.

Raytek Corp., Santa Cruz, CA, offers the Thermalert® GP two-piece infrared temperature monitoring system that combines a 1/8 DIN monitor with a rugged temperature-sensing head. It provides target temperature readings with 1% accuracy, and displays temperature data on a four-digit LED display. The monitor provides signal processing capabilities such as peak/valley hold, averaging, and adjustable offset. It features a 4-20mA output and two adjustable setpoints/deadbands.

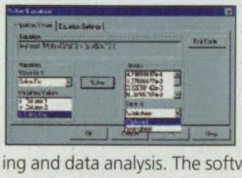
The Superprox® Model SM607 Series of small-target, ultrasonic proximity sensors from Hyde Park Electronics, Dayton, OH, combines piezoelectric transducer and microprocessor technologies, incorporating high speed and high sensitivity in the detection of very small objects and edges. The sensors have fixed-sensing windows ranging from 25 mm to 3 mm, within a sensing range of 51 mm. The sensors can detect object surfaces as small as 0.076 mm wide.

Algor, Inc., Pittsburgh, PA, offers Release 12 of its finite element analysis based mechanical engineering software. New features include a material data management system that replaces previous methods of storing and applying material data to a model. New Windows-compliant interactive model data input screens allow entering of FEA-specific model data and parameters.

The F30 miniature machine vision system from Omron Electronics, Schaumburg, IL, incorporates the elements of a machine vision system — camera lens, lighting, and processor — into a 3 x 3 x 6" assembly that can be set up in minutes. Set-up requires no programming experience and is performed using a 5-button keypad. Auto and manual inspection settings are provided.



The PenCAT/Pro® 3D pen with force-feedback from Haptic Technologies, Montreal, Canada, enables CAD designers and 3D modelers to "feel" objects on the computer screen. Users can feel curves, edges, and surface textures of the objects as they are designing, and the system can be used to replay motions directly to the user's hand. The software is combined with the PenCAT/Pro peripheral, and is bundled with add-ons and plug-ins for a variety of CAD and 3D design applications.



SPSS, Chicago, IL, offers SigmaPlot 5.0 scientific graphing software for automated graphing and data analysis. The software enables users to create exact 2D and 3D technical graphs. New features include a macro language that can be used to create custom menu choices and dialog boxes, acquire and graph data in real time, or execute analytical methods. A Function Plotter Wizard plots over 100 built-in functions by selecting a function and specifying the parameters and range.

The ICP-K233 family of 3U CompactPCI single-board computers from Inova Computers, Osterville, MA, feature a 32-bit Pentium-compatible CPU, memory, graphic controller, multiple communications options including the high-speed FireWire interface, and a range of real-time software options. The boards were designed for embedded computing applications in automation and control, and robotics. The boards feature the AMD K6 233-300 MHz processor, and provide up to 128 MB SDRAM and 24 MB FLASH RAM.

Sealant Protects Shuttle Experiments

Pelseal® 2077 sealant
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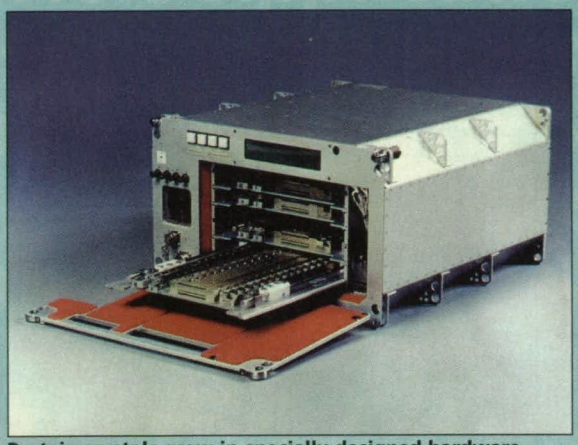
Fax: 215-245-7606
www.pelseal.com

Pelseal® 2077 sealant will play a critical role in Space Shuttle experiments that are expected to provide important information in the fight against AIDS and other diseases. First scheduled to be used for ground-based experiments during the October STS-95 shuttle mission, it subsequently will be used for on-board experiments on other missions.

A one-part sealant/caulk formulated with DuPont VITON® fluoroelastomer, the Pelseal sealant helps protect thermoelectric devices from moisture in an advanced version of the Commercial Refrigerated Incubator Module-Modified (CRIM-M), which is used to house protein crystal experiments and maintain them at a constant temperature. Scientists are studying the crystals, which grow larger and more freely in the weightlessness of space, to unlock secrets of the proteins' molecular structure. This information could help the body resist diseases such as AIDS, cancer, diabetes, sickle cell anemia, and rheumatoid arthritis.



Protein crystals grow in specially designed hardware within NASA's CRIM-M in special ground experiments at NASA's Kennedy Space Center. The box is sealed from moisture build-up with Pelseal 2077.

Protein crystals are very temperature-sensitive; to facilitate their growth, thermoelectric components in the CRIM must maintain a constant temperature in the range of 4 to 22°C, ±0.5°C. On previous flights, humidity in the shuttle condensed on the thermoelectric devices and degraded their performance. To keep the moisture from forming, a coating of Pelseal 2077 sealant was spread as a moisture barrier over the polyurethane foam that covers a metal box containing the thermoelectric components.

According to Steven Hicks, engineering lab manager with the Center for Macromolecular Crystallography in Birmingham, AL — which is conducting the program for NASA's Marshall Space Flight Center in Huntsville, AL — "the Pelseal coating functions very effectively and will allow us to conduct more reliable experiments."

For More Information Circle No. 747

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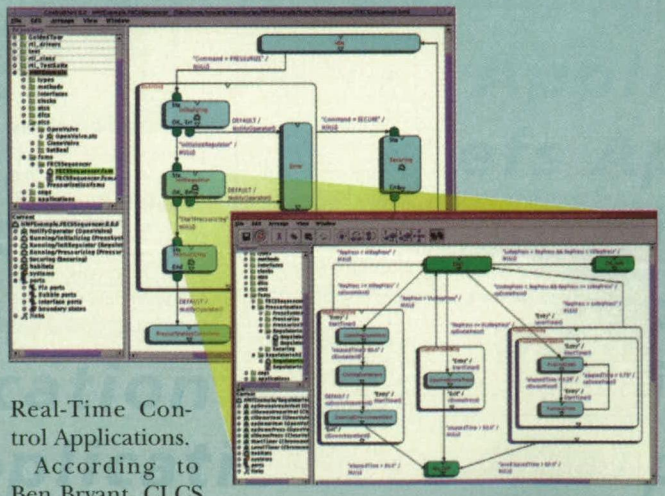
The Checkout and Launch Control System (CLCS) at NASA's Kennedy Space Center (KSC) is a $200 million mission-critical program on schedule to launch the Space Shuttle in the year 2000. The CLCS will perform all of the complex operations required to process and launch the shuttle and its various components. The CLCS Application Software developers and shuttle engineers are using ControlShell, a real-time programming system, to develop all 26 major subsystems of the next-generation launch system.

The software system is an integrated development environment that allows users to start with a global, undefined concept, and then create an object-oriented software design by decomposing the problem into interacting subsystems. It combines event-driven logic and sampled-data feedback control in an automated visual programming system that reduces design time. It is specifically designed for building real-time electromechanical systems. CLCS is using the system to develop its Real-Time Control Applications.



According to Ben Bryant, CLCS Application Software Division Chief at KSC, ControlShell's support of an object-oriented design paradigm fits with the CLCS team's concept of how to maximize reuse and reduce maintenance. It allows the system engineers to understand the application without having to know the underlying programming language. It provides "a graphical method to capture data acquisition and operational control that increases productivity and will allow us to meet our ambitious schedule," said Bryant.

For More Information Circle No. 748

Ever Dream You Could Fly?

Photography courtesy of Engineering Animation, Inc.

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Commercialization Opportunities

Bound-to-Quasi-Bound QWIPs With Random Reflectors

Random reflectors increase the light-coupling efficiency of these infrared photodetectors. Such reflector structures can be built by use of standard photolithography and selective dry etching with CCl_2F_2.

(See page 60.)

Eight-Channel WDM Fiber-Optic Data-Communication System

A proposed wavelength-division-multiplexing (WDM) optical communication system would feature a single optical fiber carrying eight channels of digital data signals. The data rate in each channel could be as high as 2.5 Gb/s.

(See page 64.)

Protective Anode Separators for Rechargeable Lithium Cells

Separators are modified to protect against internal short-circuiting in an overdischarge. The modification of the separator in a given cell is tailored to protect the most vulnerable location on the carbon electrode.

(See page 66.)

Microwave Brazing of Polycrystalline Diamond Onto Drill Bits

This technique would be used to fabricate diamond-covered cutting tool bits. These bits would be designed to withstand higher hard-rock-drilling temperatures of up to 900 °C.

(See page 68.)

Manipulation of Liquids by Use of Sound: Part I

Acoustic-radiation-pressure phased arrays currently undergoing development are envisioned as general purpose nonintrusive tools for manipulating both liquids and objects suspended in liquids. This concept is similar in principle to the phased-array antennas. Only here, acoustic, rather than electromagnetic, beams are steered and focused in the desired directions.

(See page 72.)

Miniature Joule-Thomson Rankine-Cycle Refrigerators

Lightweight, low-power refrigerators are proposed for cooling portable scientific instruments. These refrigerators would be made largely from silicon wafers by micromachining techniques like those used to fabricate integrated circuits.

(See page 76.)

Microgravity Fiber-Pulling Apparatus

A new process has been developed to produce optical fiber composed of the heavy-metal fluoride glass. Such fibers are usually difficult to process in ground-based operations because this glass has low viscosity, a narrow working range, and a tendency to form crystallites.

(See page 79.)

New Metallic Seal Provides Exceptional "Springback"

Busak+Shamban has introduced the Wills Rings® C, the newest member in a full line of high-performance metallic seals.

The Wills Rings® C has an innovative C-shaped profile with springback ability up to three times greater than conventional metallic O-rings. This springback ability can compensate for hardware changes due to extreme pressure and temperature variations. These seals also feature superior static sealing performance for the most demanding applications.

The low seating load of the Wills Rings® C results in a size and weight reduction of the mating hardware. In addition, the system pressure energizes the seal profile to enhance the leak-tight seal performance. For applications requiring an extra measure of security, the Wills Rings® C can be coated with either silver or PTFE in a variety of thicknesses.

The addition of the pressure-actuated Wills Rings® C increases an already broad product line of Wills Rings® that includes solid, hollow and gas-filled metal seals. The Wills Rings® product line is the original metallic seal line used throughout the chemical, nuclear, aerospace and automotive industries where the ability to cope with extreme temperatures, pressures and media is essential.

Capabilities of the Wills Rings® includes temperatures ranging from cryogenic to 1550°F (850°C) and pressures from ultra high vacuum to 145,000 psi (1000Mpa). Leakage rates in an ultra high vacuum are below 10^{-9} cc/sec (1.01×10^{-9} mbar•liter/sec).

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For further information about Wills Rings® call Pat Haggerty at 1-800-466-1727.

For More Information Circle No. 572

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For More Information Circle No. 573

Designing With Help of Neural-Network and Parallel Computing

Large design problems can be solved faster and more efficiently than before.

Lewis Research Center, Cleveland, Ohio

Structural Analysis/Design (STRAND) and Neural Net Computation (NETCOM) are developmental modular computer programs that exploit the speedup afforded by parallel and neural-network computing to drastically reduce the computation time needed to solve large design-optimization problems. These programs were originally intended for use in designing aerospace structures, but, when fully developed, will also be useful for optimizing designs of diverse nonaerospace structures, including high-rise buildings, automobile structures, and civil infrastructures.

STRAND and NETCOM have been integrated into PAR_STRAND_NET, which is a self-contained software system that can be implemented on either PVM or MPI standard networked parallel clusters of computer workstations and IBM SP computers. The figure shows the macro flow chart of PAR_STRAND_NET.

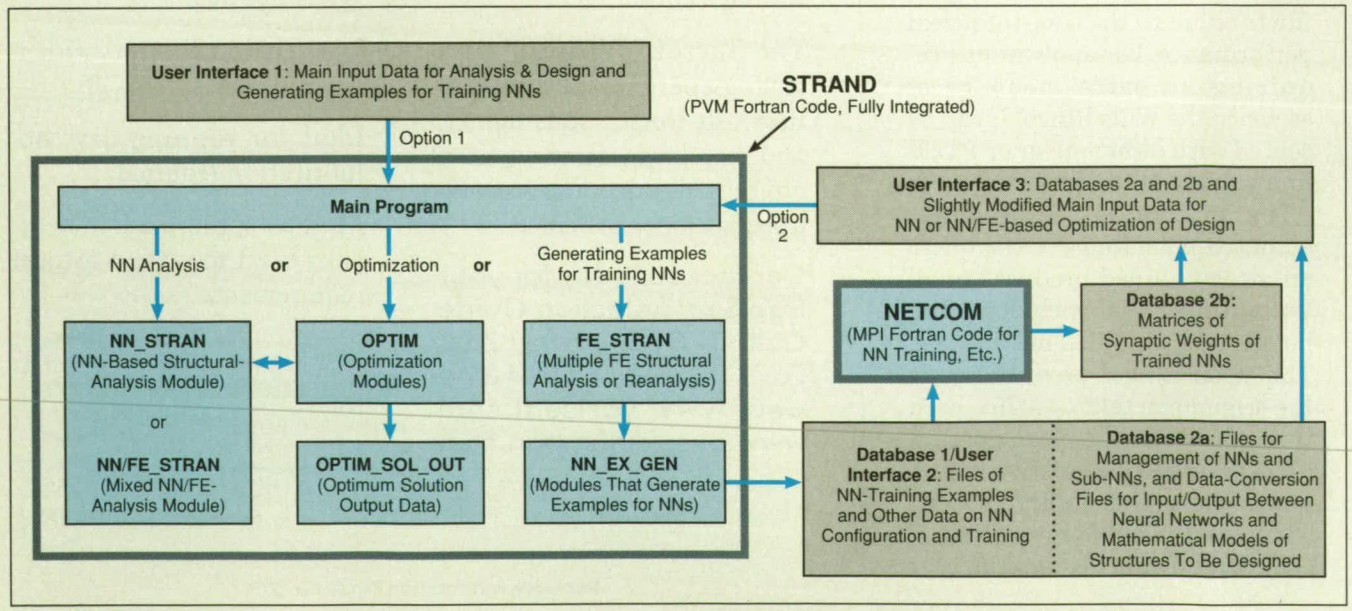
STRAND can perform automated design-optimization computations based on neural-network (NN), finite-element (FE), and mixed NN/FE analysis methods. STRAND affords computational capabilities to perform tasks as follows:

- Multiple concurrent structural analyses can be performed by use of parallel multiple FE and/or NN analysis methods and modules.
- Parallel optimization of structural design can be accomplished by use of FE and/or NN structural-analysis modules and an optimization module. The module implements the Integral Global /Local Optimization (IGLO) algorithm, which performs stochastic global and local searches. Built-in objective functions of structural weight, strain energy, and maximum displacement are used in optimization.
- Training examples and data bases for training neural networks can be created by use of concurrent multiple FE structural-analysis modules and a scaled-training-example data-reduction module.

NETCOM is capable of training multiple NNs or sub-NNs in parallel and of predicting NN output quantities by use of trained NNs. Training in NETCOM is effected by the back-propagation algorithm. A capability for concurrent training of multiple NNs or sub-NNs can be utilized in cases in which (1) the NNs or sub-NNs share the same input vector (typically, the same set of cross-sectional areas of structural members or of other design variables) but (2) the NNs or sub-NNs generate different output vectors (e.g., displacement vs. stress vectors) or numerically differing components of the same output vector. Once NN training has been completed, NETCOM generates a second data base that contains the matrices of synaptic weights of the trained NNs.

The use of NNs to replace FE reanalysis in the optimization of a structural design can reduce computational time by nearly an order of magnitude — an important advantage in the case of a large-scale design. Ordinarily, this advantage would be offset by the tedious and time-consuming nature of NN training. However, in this system, computational burden of NN training is reduced by the use of reduced NN models plus the efficient parallel and NN computational capabilities of NETCOM.

On the basis of numerical performance in tests conducted thus far, the IGLO algorithm was found to be much more efficient than are such other stochastic algorithms as those of the genetic and simulated-annealing types.



The **PAR_STRAND_NET Software System** utilizes a combination of neural-network, finite-element, stochastic-optimization, and parallel-computation techniques to reduce the computation time needed to solve large design-optimization problems.

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Thus, it appears that IGLO offers great potential for solving large-scale design problems that involve not only continuous design variables but also discrete variables and mixes of continuous and discrete variables.

One likely goal of future development efforts would be to secure the advantages while avoiding the disadvantages of both gradient-based optimization (GBO) methods and stochastic methods like those of IGLO. GBO methods are inapplicable to mixed- and discrete-variable problems, and sometimes yield solutions that are not optimum in the sense that they correspond to local minima that differ from global minima of objective functions in design-variable space. On the other hand, whereas stochastic methods yield global solutions for continuous, discrete, and mixed variables, much more computation time is needed to find a local minimum in a stochastic method than in a GBO method. Therefore, it appears desirable to replace the continuous-local-search portion of the IGLO algorithm with a GBO algorithm to form an integrated IGLO/GBO algorithm to increase computational efficiency and the quality of solutions of problems that involve continuous, discrete, and mixed variables.

This work was done by Rong C. Shieh of MRJ Technology Solutions for **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16601.

Modular, Extensible Program Simulates Dynamics of Systems

This program lends itself well to analyses in which frequent changes of code are necessary.

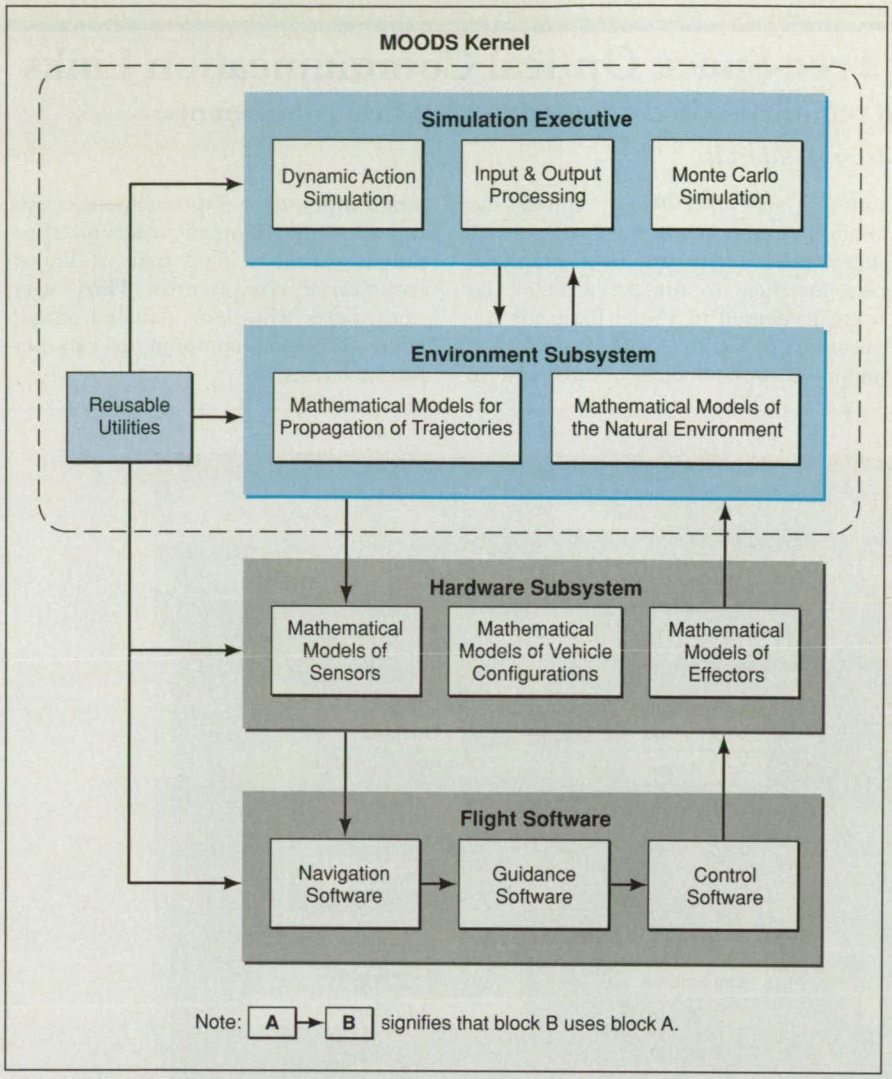
Lyndon B. Johnson Space Center, Houston, Texas

The Multiple Object Orbital Dynamics Simulation (MOODS) computer program is a general, extensible, easily modifiable, and reusable software system for use in simulating the dynamics of such diverse engineering systems as aircraft, missiles, automobiles, industrial process-control systems, or other systems wherein time-dependent physical processes (e.g., unsteady chemical reactions) occur. MOODS contains a generic and reusable kernel, plus a large base of high-quality reusable primitives, utility subprograms, and models that assist it in rapidly prototyping extensions of itself and of other system-analysis application programs.

Among the components of MOODS are the following:

1. Primitive objects, mathematical types, and functions (vector, matrix, complex, and quaternion operators);
2. Statistical utilities (e.g., random-number generators);
3. Numerical methods; and
4. Data-structure and computer-science utilities (stacks, queues, dynamic arrays, and queued interface mechanisms).

Unlike other simulation programs, MOODS, was not designed to support high-data-volume production runs — although it can be modified to be driven with external input files.



The **MOODS Software System** is general, extensible, easily modifiable, and reusable. In the configuration depicted here, MOODS is used to simulate trajectories of many orbital objects.

MOODS can be modified easily to support changing analysis requirements. Its kernel set of software tools is exhaustive; this facilitates extensions of the program. If a developmental code is based largely on pre-existing reusable components, then only a minimal amount of new code is needed. Moreover, MOODS requires frequent recompilation of its input unit; this makes initialization of a MOODS simulation extremely flexible.

MOODS must be flexible because it works in a rapidly changing environment; more specifically, in its original application in the U.S. space program, it simulates the trajectories of a large number of orbital objects. The main subsystems of MOODS as configured for this application (see figure) are (1) a simulation executive subsystem, (2) an environment subsystem, (3) a set of reusable utilities, (4) a hardware subsystem, and (5) a flight-software subsystem. The machine-independent MOODS kernel comprises the first three mentioned subsystems.

The MOODS kernel is a collection of roughly 211 Ada units. Its source code is partitioned on a VAC computer into 347 files that occupy 1.9MB of memory space. The object code occupies 602KB of memory space. Because each kernel utility is generic and reusable, extension of the capability of the program involves only a minimal amount of development of new code.

The uniqueness and greatest strength of MOODS lie in its suitability for system-analysis and -development projects in which frequent changes in dynamics-simulating computer codes are necessary. MOODS is user-friendly. Its flexibility and reusability should prove as valuable to industry as they have already proved in the U.S. space program.

This work was done by Roger W. Corson, Michael J. Little, and Jeffrey S. Patterson of McDonnell Douglas for **Johnson Space Center.** *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Information Sciences category.*

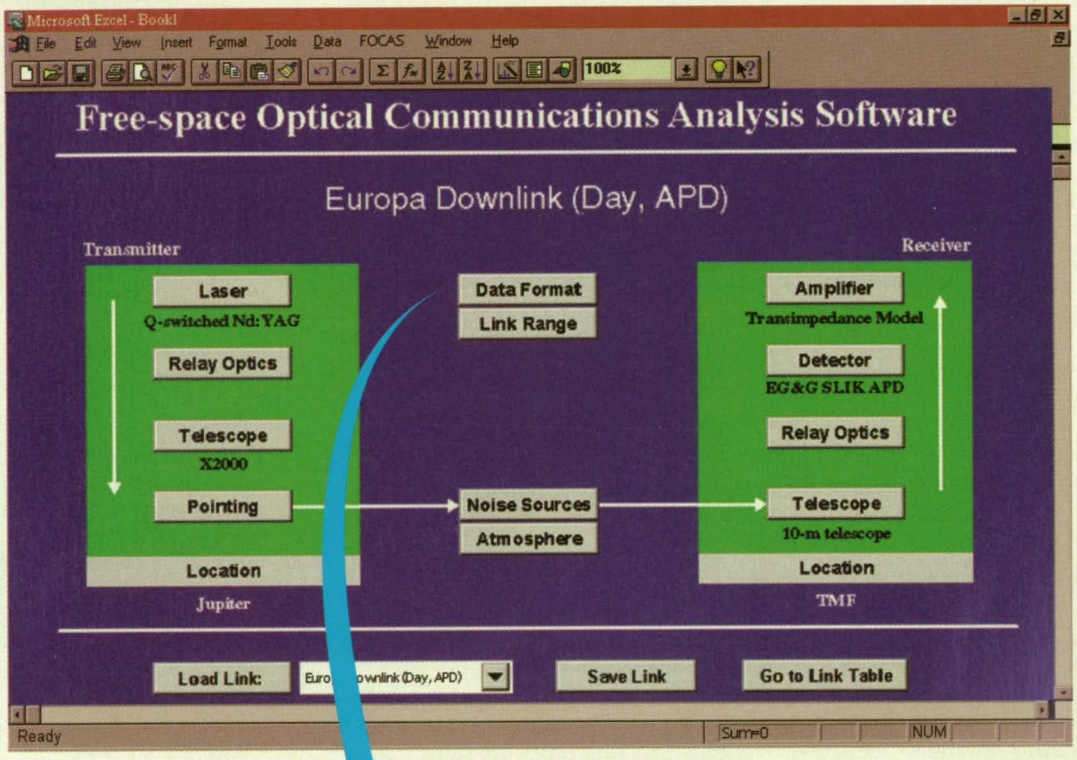
MSC-22527

Program for Analyzing Free-Space Optical Communication Links

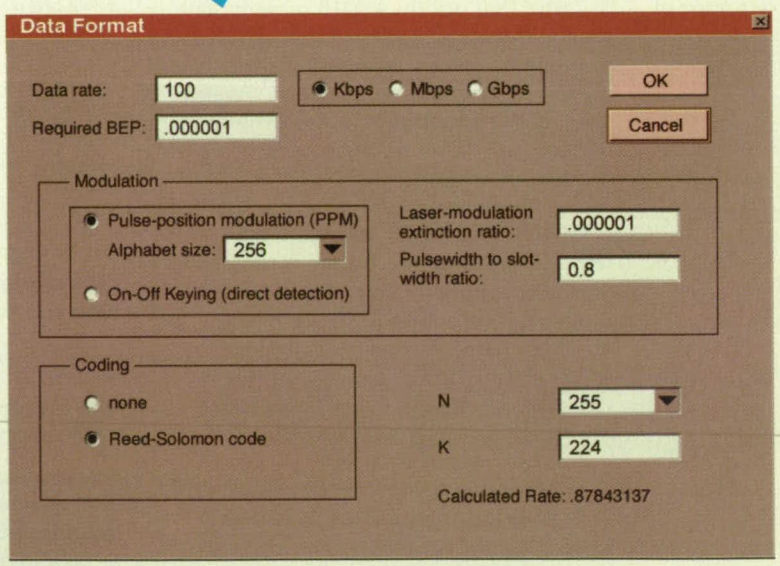
This easy-to-use program does not require detailed knowledge of optical components.

NASA's Jet Propulsion Laboratory, Pasadena, California

"Free-Space Optical Communications Analysis Software" (FOCAS) is the name of a spreadsheet computer program for analysis of direct-detection (as distinguished from heterodyne-detection) optical data-communication links. Implemented within the Microsoft Excel software system, FOCAS exploits the flexibility and power of the Excel spreadsheet features. An easy-to-use graphical user interface to the spreadsheet has been developed in Visual Basic for Applications to facilitate insertion of parameters of optical components and of other input data. Optionally, the user can select the automatic insertion of parameters from a data base of known commercial components. Thus, even nonexperts who lack detailed knowledge of optical components can perform analyses.



DISPLAY CONTAINING A BLOCK DIAGRAM



EXAMPLE OF A DIALOG BOX

FOCAS Displays a Block Diagram of an optical communication link. Through each block in the diagram, the user can bring up a dialog box (in this example, the Data Format box) to edit parameters of the aspect of the link represented by the block.

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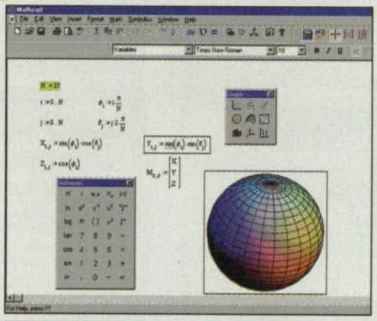

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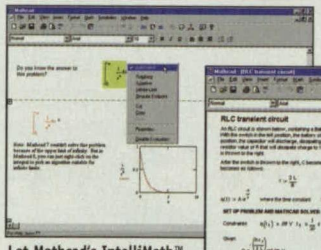

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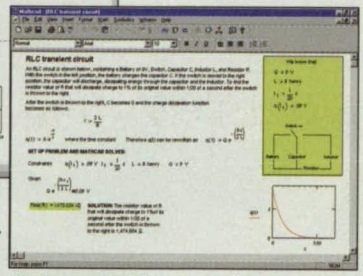

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The following is a partial list of communication-link features accommodated in FOCAS.

- Modulation schemes: on/off keying and M-ary pulse-position modulation, including Manchester coding (binary PPM) as a special case of M-ary PPM.
- Coding: Reed-Solomon code with choice of code-word length and number of information symbols.
- Lasers: Energy-storage-based pulsed lasers or continuous-wave lasers with current modulation or external modulators.
- Transmitter and Receiver Optics: Gains, beam widths, and related parameters are calculated for Gaussian or near-diffraction-limited beam profiles. The effect of transmitting-telescope wavefront quality is incorporated in the Strehl ratio.
- Detectors: Quantum efficiencies of positive/intrinsic/negative (PIN) photodetectors, avalanche photodetectors (APDs) and photomultiplier tubes (PMTs) are represented by lookup tables. Gaussian statistics are used for PIN photodetectors and APDs; Poisson statistics are used for PMTs.
- Amplifiers: Noise, frequency response, and other characteristics of transimpedance and high-impedance preamplifiers can be obtained by use of mathematical models or by selection of amplifiers listed in the data base.
- Other: Wavelength- and zenith-angle-dependent atmospheric-transmission data and wavelength-dependent sky-radiance data are obtained from another program called "MODTRAN." By use of a Rician probability model, FOCAS calculates burst error probability due to pointing jitter and bias. Link ranges are determined automatically for given transmitter and receiver locations.

When FOCAS is opened in Excel, the program displays a block diagram of an optical communication link, including a transmitter, a free-space optical communication medium or channel containing noise sources, and a receiver (see figure). Each block in the diagram appears as a button that can be pressed to bring up a dialog box, through which the user can view and edit the parameters of the transmitting or receiving component, transmitting or receiving subsystem, channel, or link characteristic represented by the block. Other buttons below the block diagram enable the user to load or save parameters or view a link table, which is described below.

In a typical case, the user clicks on the buttons to enter the link parameters manually or, where desired, automatically by selection of a component from the data base. FOCAS automatically compares each parameter with minimum and maximum values to generate a warning and/or prevent the entry of a physically unrealistic value; for example, if the user attempts to enter a beam width less than the diffraction-limit minimum for a selected telescope diameter, then FOCAS displays an error message and does not allow the user to proceed further until the user enters a larger, realistic value.

Once all input parameters have been entered, the user can cause the program to display the link table by pressing the "Go to Link Table" button. The link table is a spreadsheet that shows both the input parameters and the values calculated by the program. The link table is divided into a link summary and a detailed link section. The link summary section contains parameters that characterize the overall link, including the overall link margin, link range, data rate, bit-error rate, transmitted power, received power, power required to achieve a specified overall link margin, transmitter gain, receiver gain, and terms that account for losses

along the link path. The detailed link section follows the link summary section and consists of subsections (transmitter, channel, receiver, link margin, coding, calculation of required signal power, and background radiation), each of which provides information in depth on one aspect of the link.

Almost all of the cells in the link table are locked to prevent the user from inadvertently changing dependent variables calculated by the program. However, the user would find it inconvenient to go back to the dialog boxes to change the values of some common parameters in performing a series of related analyses. Therefore, FOCAS allows some of the parameters (for example, the link range, data rate, average laser power, width of the transmitted beam, and the diameter of the receiver aperture) to be changed in the link table. Following such changes, the auto-calculation feature of Excel updates the remainder of the link table; thus, FOCAS provides an interactive means of designing an optical communication link.

This work was done by Muthu Jeganathan, G. Stephen Mecherle, and James Lesh of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*
NPO-20412

Knowledge-Based Reasoning Tool for Diagnosing a Complex Flow System

This program is designed as a real-time aid to analyze system health.

John F. Kennedy Space Center, Florida

The Propulsion Advisory Tool (PAT) is a knowledge-based computer program that monitors real-time data from more than 300 sensors in the space shuttle Main Propulsion System (MPS). The thermal conditions within the launch pad storage/transfer facility, MPS, and External Tank (ET) must be monitored during the propellant-loading process in order to maintain subcooled cryogenic-liquid conditions and prevent an LO_2 geyser. The PAT knowledge base can provide a quick and accurate assessment of an anomaly by identifying both actual and potential system failures in addition to pertinent data for anomaly resolution.

In the terminology of artificial intelligence, this software is characterized as a knowledge-based reasoning tool. The knowledge base is coded using a natural language interface (plain English) and is developed based on existing requirements documents and knowledge captured from experts working in the propulsion arena. In this way, the expert system works within a framework similar to the way humans would; a system based on human logic and reasoning on quantitative real-time data.

The knowledge base was developed using a hybrid methodology of commercial off-the-shelf (COTS) tools and custom computer code. The COTS tools currently used in the PAT system are Gensym's G2 expert system shell and Oracle. Relational data bases containing real-time, full-rate shuttle data are used to assess the health of the data coming from the vehicle. The PAT uses rule and model-based approaches for the analysis of system health. Rules are used primarily for limit checking, formulating diagnostics, determining state conditions, and user interface tasks. The model base evaluates system configuration and component connectivity.

Pressure, temperature, and flowrates within the propellant loading system can be calculated, and the information can then be extrapolated in order to infer fluid conditions in other locations. Objects representing pressure and temperature sensors contain both the true system redline conditions and engineering estimates of what their values should be for each phase of the propellant load process. For a visual reference, the current value of key pressure/temperature sensors are plotted against the theoretical saturation curve.

Component electrical circuits have been modeled within the G2 knowledge base to reflect the active current path. The electrical circuit shows "live" wires along with active objects that represent the various talkbacks within the circuit. The power of this feature is that the systems engineer can directly relate the data provided by the orbiter with

the paper-based drawings that describe the circuit design.

PAT displays include a page that informs the user of the current step in the propellant-loading procedure. Another display shows the loading system schematic. The components within the system are represented as live objects with user-defined attributes. Selecting these objects displays detailed information about that object. In addition, the fluid lines are colorized based upon the phase conditions of the propellant.

The PAT knowledge base will be part the expert-system tools for the next generation of shuttle-launch-processing software, referred to as the Checkout & Launch Control System (CLCS). In addition, the PAT software is used on the day of launch in the Launch Control Center at KSC for each shuttle mission. The PAT knowledge base architecture has been used as a prototype to design and as a basis for building several expert systems, one of which includes command and control for the ground checkout of flight-test hardware.

This work was done by Laurence H. Fineberg, James M. Engle, Anton C. Melichar, James R. Lane, John A. Marinuzzi, Jose Gallardo, Jim Howarth, Janice L. Lessman, and Manuel Beltran of Boeing North American Corp. for **Kennedy Space Center.**

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Kennedy Space Center; (407) 867-6225. Refer to KSC-11902.

Software for Analysis and Design of Turbomachinery Seals

These programs can be used to design seals to improve overall machine performance.

Lewis Research Center, Cleveland, Ohio

Several computer programs, denoted collectively as the "CFD Seal Analysis Industrial Codes," have been developed to enable rapid parametric analyses and optimization of designs of a variety of turbomachinery seals. These programs could be used to design the seals that will be needed in future air-breathing and other aerospace systems, with improvements to enhance efficiency, prevent leakage, control flows of lubricants and coolants, prevent the entry of contaminants, inhibit mixing of incompatible fluids, and assist in controlling dynamic responses of rotors.

One of the programs is GCYL (Gas Cylindrical Seals), which can be used to analyze a variety of cylindrical seals, including ones with steps, tapers, and hydrostatic geometries. This code is a Reynolds-equation solver that accommodates laminar and turbulent flows in the film region. This code is principally applicable to seals with low-clearance geometries; for example, floating ring and circumferential sectored seals. This code computes clearance and pressure distributions, leakage, interface loads, righting moments, viscous dissipation, and frequency-dependent coefficients of stiffness and damping. Plotting routines are also provided to aid the visualization of clearance and pressure distributions. This code can be applied to seals for compressors, industrial gas turbines, and jet engines. It has also been applied to helium buffer seals for cryogenic pumps.

The Gas Face Seals (GFACE) program is similar to GCYL except that it applies to face geometries.

The Spiral-Groove Gas Seals (SPIRALG) program can be used to analyze spiral-groove, cylindrical, and face seals. Spiral-groove seals are becoming widely used in gas compressors, gas circulators, and computer disk drives. In SPIRALG, flow is assumed to be laminar and isothermal and to take place in narrow grooves. SPIRALG computes forces, moments, film thicknesses, leakage, power losses, and cross-coupled, frequency-dependent stiffness and damping coefficients.

The Spiral-Groove Liquid (Incompressible) Seals (SPIRALI) program is based on Hir's bulk-flow model with the addition of spiral-groove theory. Turbulence is treated with an extended form of Hir's bulk-flow model, generalized to include separate and arbitrary friction-factor Reynolds-number relationships for each surface. Film inertia is treated globally. Narrow-groove theory is used to characterize spiral grooves, maintaining the global representation. For geometries with film discontinuities (for example, with parallel and multiple helical grooves), loss coefficients are used. Effects of rough surfaces can also be modeled by applying friction-factor relationships. As in the case of SPIRALG, the output of SPIRALI includes forces, moments, film thicknesses, leakage, power losses, and cross-coupled, frequency-dependent stiffness and damping coefficients. One can also use SPIRALI to analyze pressure-breakdown bushings, wearing rings, and damping seals for high-pressure pumps and cryogenic turbomachines.

The Liquid (Incompressible) Cylindrical Seals (ICYL) program affords capabilities for analyzing two-dimensional, incompressible, isoviscous, turbulent flow in a cylindrical geometry; rotation of a rotor and/or a housing; roughness of both the rotor and the housing; and inertial pressure drops at inlets to fluid films from the ends of a seal and from pressurized pockets. Inertial effects are incorporated by applying a Bernoulli relation at each boundary point and reducing the static pressure by the computed kinetic-energy density. Capabilities for modeling Couette and Poiseuille flow, turbulence, and cavitation are included. Such geometric features as steps, pockets, tapers, preload arcs, and hydrostatic recesses can be treated. ICYL computes pressure and clearance distributions, rotor position, forces, moments, pocket pressures and flows, and cross-coupled coefficients of stiffness and damping. Plotting routines are included in ICYL. Applications for ICYL include liquid hydrostatic and hydrodynamic seals for pumps, cryogenic machines, and miscellaneous machinery.

The Liquid (Incompressible) Face Seals (IFACE) program is similar to ICYL, except that it applies to face seals rather than to cylindrical seals.

The Knife-to-Knife Analysis of Labyrinth Seals (KTK) program computes leakages and distributions of pressure through labyrinth seals. Applications include all gas-seal turbomachinery. Both straight-through and step labyrinths are considered. Input data are required to describe the geometry of a seal and the environmental conditions that affect leakage. Output is provided in the form of flow and flow-resistance characteristics; for ex-

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For More Information Circle No. 537

ample, flow factor versus pressure ratio. An optimization feature included in the program enables the user to identify global geometric constraints and enables the program to identify an optimum seal configuration based on minimum leakage.

The Dynamic Response of Seals (DYSEAL) program determines the tracking capabilities of fluid-film seals and can be used to analyze effects of parametric variations in geometry to improve dynamic responses. This code can be used to analyze face seals and floating-ring cylindrical seals. In the case of a face seal, the rotating or mating ring can be treated as vibrating in five degrees of freedom — translations along three Cartesian axes (x, y, and z) and rotations about two of these axes (x and y). The response of the seal ring is also modeled in five degrees of freedom. The interface is represented by cross-coupled stiffness and damping coefficients obtained from other programs. The effects of Coulomb friction of secondary seals on the seal-ring response are included. Input options for piston-ring and O-ring secondary seals are provided. The floating-ring-analysis portion of this program accommodates two degrees of freedom for both the seal and the ring, and is intended to determine the response of the ring to an orbiting shaft. A secondary seal occurs between a ring and a wall, and the x-y Coulomb friction there is taken into account. The general method of computation is a forward integration in time that yields absolute motions in all degrees of freedom. At every time step, friction must be evaluated to determine whether motions continue or are halted.

A graphical user interface (GUI) program couples the aforementioned programs through system executive software. Input is prepared with the help of menus, dialogue boxes, and button options, in a manner similar to that of the Windows operating system prevalent in contemporary personal-computer usage. Input files can be prepared manually by use of text-editor software, and the instructions for doing so are included in the technical manuals for the individual programs.

The CFD Seal Analysis Industrial Codes collection is written in FORTRAN 77 for IBM-PC-compatible computers running the OS/2 operating system. A random-access memory of at least 8MB is recommended. A computer based on an 80386 or 80486SX processor must include a math coprocessor. Executable code is provided. The software has been successfully implemented on '486-class IBM personal computers with version 2.1 (and more recent versions) of the OS/2 operating system. Source code can be compiled on such other operating systems as Windows 95 or Windows NT. A Watcom FORTRAN 77 compiler is necessary for compiling this software. The GUI will be available under OS/2 only. The standard distribution medium is a set of nine 3.5-in. (8.89-cm), 1.44MB MS-DOS-format diskettes.

This program was written by W. Shapiro, B. B. Aggarwal, J. Walowit, and A. F. Artilles of Mechanical Technology, Inc., for **Lewis Research Center.** *The KTK program was written by R. E. Chupp, G. F. Holle, and T. E. Scott of Allison Gas Turbine, a division of General Motors Corporation, and was included in the CFD Industrial Codes with the permission of the U.S. Air Force.*

For further information, access the Technical Support Package (TSP) ***free on-line at www.nasatech.com*** *under the Software category.*

LEW-16582

Software for Qualitative Flow-Path Modeling of Systems

This program can be used in simulating behaviors of systems affected by operational events.

Lyndon B. Johnson Space Center, Houston, Texas

A computer program called "the explicit global-modeling tool" implements a dynamic method of operation by which researchers can (1) determine global flow-path changes that occur during computational simulations of the behaviors of engineering systems; (2) analyze both normal and faulty qualitative system behavior; and (3) identify the corresponding local changes, caused by operational events or failures, in mathematical models of such systems. The program is a generic device-modeling tool that effects a software version of human qualitative analysis of device behavior.

Although progress has been made in qualitative modeling and analysis of perturbations in electrical circuits, by use of graph clustering (which is a continuous system-modeling method), the method implemented in the explicit global-modeling tool provides a significant advance over the continuous system-modeling method. In continuous system modeling, conventional numerical analysis is used to compute quantitative values of the behavior of a system and its components in each steady state. Analysis of dynamics involves solving equations for all proposed topologies and comparing these results to derive changed values; this is a very complex process, and in order to be able to effect the process, one must identify the dynamic topologies and appropriate simplifications and statistical assumptions for the system to be analyzed.

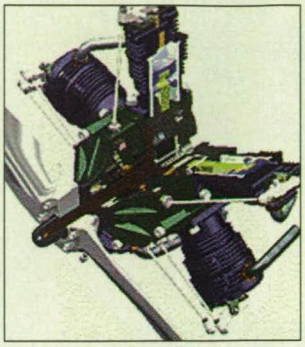
In contrast, the explicit global-modeling tool implements a method compatible with local modeling, discrete simulation, and analysis. Far less complex than any computer program developed previously for the same purpose, this program disentangles important global system-power-transmission variables from local component variables. This program thus supports abstracted general-purpose local mathematical models, and does not require the development of multiple-system, configuration-specific mathematical models for each component as is required in continuous system modeling.

The basis of the design of the explicit global-modeling tool is a data structure and algorithms in which flow-path elements communicate with one or more parent objects. Each parent object represents a subgraph of an overall flow network in a modeled system. During simulations, the elements report information on their local states, and the parent objects report to their elements the statuses of flow-related attributes of the subgraphs — e.g., whether an external flow into a subgraph occurs because of sources external to that subgraph.

The qualitative method of abstraction used in the explicit global-modeling tool supports the use of discrete-event-simulation approaches in analyzing analog systems. The power-transmission abstraction and clustering approach also afford broad applicability to several discrete and analog domains, and to such analysis domains as reliability block-diagram analysis. The program has already been demonstrated to be especially useful in applications of the type for which it was designed; namely, analysis of spacecraft equipment systems. Other, industrial uses are expected to evolve as the program becomes modified in subsequent development efforts.

This work was done by Jane T. Malin of **Johnson Space Center** *and Land D. Fleming of Hernandez Engineering, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Information Sciences category.*

This invention has been patented by NASA (U.S. Patent No. 5,732,192). Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22618.



SolidWorks Corp., Concord, MA, has introduced SolidWorks 98Plus **3D mechanical design software** that includes enhancements in the user interface, detailing, assembly design, surfacing, and sheet-metal design capabilities. Key detailing additions include the ability to embed custom properties in a drawing template; automatic crosshatch control for assembly section views; and Dynamic View Activation for automatically activating a view sheet depending on cursor location. Assembly modeling enhancements include Snap-to-Fit Smart Mates that automatically captures assembly-mating relationships; and the ability to open large assemblies up to 300 percent faster.

Simplified access to and reuse of standard parts and features has been added. A new Shape feature allows users to manipulate faces using pressures, points, and curves to create free-form shapes.

For More Information Circle No. 719

The CADKEY Design Suite **PC-CAD toolset** from Baystate Technologies, Marlborough, MA, features CADKEY® 98 mechanical 3D/2D CAD software, ACIS® 4.0 modeling technology, FastSOLID™ solid modeling technology, FastSURF® surface modeling, and DRAFT-PAK® machine design productivity toolset. The suite enables users to modify solids, surfaces, or wireframe models without constraints, as well as generate 2D engineering drawings using CADKEY's 3D model-to-drawing associativity.

Engineers can verify the integrity of CAD databases received from other CAD/CAE/CAM systems in CADKEY before going onto the toolpath generation phase. The suite also incorporates a new STEP™ Translator and AutoCAD® R14 File Format support with existing data translators such as IGES, DXF, STL, and VRML, for importing or exporting 2D/3D data to other ACIS-enabled applications. The software operates on Windows 95/NT platforms.

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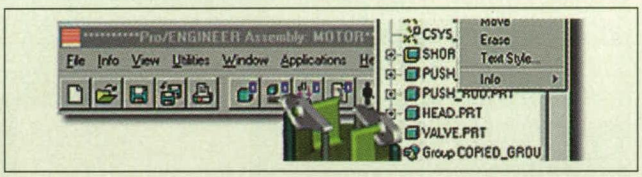
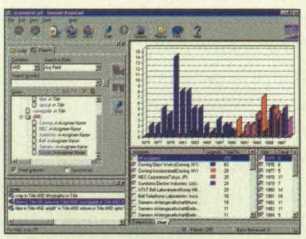


Parametric Technology Corp., Waltham, MA, offers Release 20 of Pro/ENGINEER" Solutions **product development software**, which includes a new user interface with a menu bar that consolidates all top-level commands into a familiar industry interface, a customizable tool bar, and consolidated dialog boxes. 3D Notes allows users to display product information within the context of the 3D model by using Web communication capabilities within the modeling environment.

The Intent Manager sketcher feature allows users to sketch and stretch ideas without interrupting the creative process. It makes intelligent assumptions and provides immediate visible feedback to the user during sketching. The sketches are fully and automatically dimensioned without user intervention, ensuring the accurate capture of the product's design intent through a modifiable sketch.

For More Information Circle No. 720



Invention Machine Corp., Boston, MA, has introduced TechOptimizer™ 3.0 **knowledge-based problem-solving software** that enables users to state engineering problems correctly, create new engineering concepts, and manage technical knowledge. The new Internet Assistant Module automatically conducts a Web search of desired technical effects and related information. A Patent Analyzer function enables users to conduct searches via the Internet and the U.S. Patent Office database. This provides the capability to perform competitive analysis on intellectual activity, by company and by technology.

Other modules include the Product Analysis Module, which identifies key functional requirements of the system and generates correct problem statements; the Process Analysis Module, which analyzes the sequence of technological operations used in manufacturing; and the Effects Module, which provides access to over 4,400 animated engineering and scientific effects and examples.

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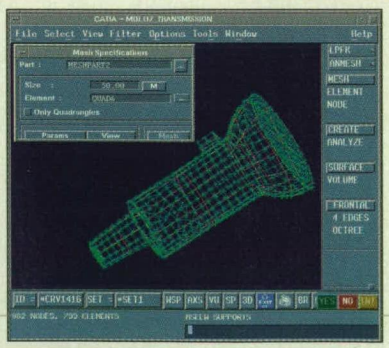
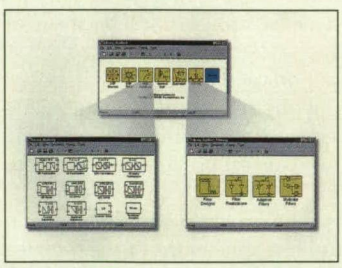


CAT/COMET **acoustic analysis software** for CATIA from Automated Analysis Corp., Ann Arbor, MI, integrates design, structure, acoustics, and vibration data. Embedded in the CATIA Analysis environment from Dassault Systemes, the software generates acoustic analysis solutions using CATIA's automatic surface meshing. The software was designed to work in the CAD environment and facilitate collaborative efforts among development teams.

Used in the design and analysis cycle, the software predicts sound performance and supplies information to the user on how to achieve noise reduction and improve sound quality, providing the link from the user's current structural analysis software or test data, to acoustic performance results.

For More Information Circle No. 721



The MathWorks, Natick, MA, offers a new version of the DSP Workshop **DSP design and simulation software**, which includes MATLAB, Simulink, DSP Blockset, and Signal Processing Toolbox. Architectural improvements in the DSP Blockset provide streamlined design cycles, and support for frame-based processing allows users to process blocks of data and individual data samples within a time-driven simulation. Each block automatically adapts to the incoming signal's data type, sampling rate, and frame size.

The enhanced Simulink contains data types, sample-rate propagation, and support for multi-rate systems that support a natural design of real-time DSP algorithms, as well as simulation of large-scale communication systems. Users can move MATLAB-based algorithms directly into simulations that mirror the operation of the DSP processor and map to the real-time implementation.

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Ridged Tracks for Guiding Magnetic Bubbles

Ridges offer advantages over grooves.

NASA's Jet Propulsion Laboratory, Pasadena, California

Tracks for the guidance of magnetic bubbles propagating in the input and output lines of Vertical-Bloch-Line memory devices can be made in the form of ridges instead of in the traditional form of grooves. The ridge-type tracks offer advantages over the groove-type tracks, as explained below.

A track is formed on a substrate made of suitable magnetic material; namely, a garnet film. A gradient of the vertical magnetic field is associated with a step in the thickness of the film; the field increases as one proceeds from a location where the film is thinner to a location where it is thicker. Thus, in the case of a groove, the field increases as one crosses either wall of the groove from the inside to the outside. Because the stable position of a magnetic bubble lies at a local minimum of the field, a bubble that has been propagating along the groove remains confined in the groove.

The spatial variation of the field is, however, slightly more complex than is the spatial variation in thickness (see figure). The field increases slightly from the wall toward the middle of a groove. Thus, there are shallow local field minima along the sides of a groove. If the groove is wider than about 1.5 bubble diameters, then a bubble tends to move sometimes along one side, sometimes along the other side, moving back and forth in mostly random fashion as it propagates along the groove. If the groove is narrower than about 1.3 bubble diameters, a bubble remains centered in the groove but propagates more slowly than it would if the groove were wider. The customary groove width of 1.5 bubble diameters is a compromise that entails a little of both slowing down and meandering of bubbles.

A ridge-type track is formed by etching wide grooves on both sides of the track. Mirroring the situation in a groove, the magnetic field rises to maxima near the two side walls of the track, while at the middle of the track, the field falls to a local minimum that is isolated from the deeper minima of the adjacent grooves. The confinement gradient of a ridge is weaker than that of a groove, but still adequate for guidance. Unlike a groove track, a ridge track can be made wider than 1.3 bubble diameters without incurring meandering of bubbles; a ridge as wide as 2.5 bubble diameters can provide excellent guidance.

Another advantage of a ridge-type track over a groove-type track arises in connection with the need to expand a bubble into a stripe when it reaches the end of the track, in preparation for detection of the bubble by use of a magnetoresistive strip. In the case of a groove-type track, the bubble expander is a mesa with its top recessed slightly below the surrounding garnet surface. An electric current in a helper loop is needed to provide a momentary additional magnetic field to lift a bubble from the groove, over the potential barrier at the edge of the mesa, so that the bubble can then stripe out on top of the mesa.

In the case of a ridge-type track, the track can simply be terminated in a mesa-type expander of the same height as that of the ridge. There being no step discontinuity in height, there is no need for a helper loop to move the bubble out onto the expander.

This work was done by Udo Lieneweg of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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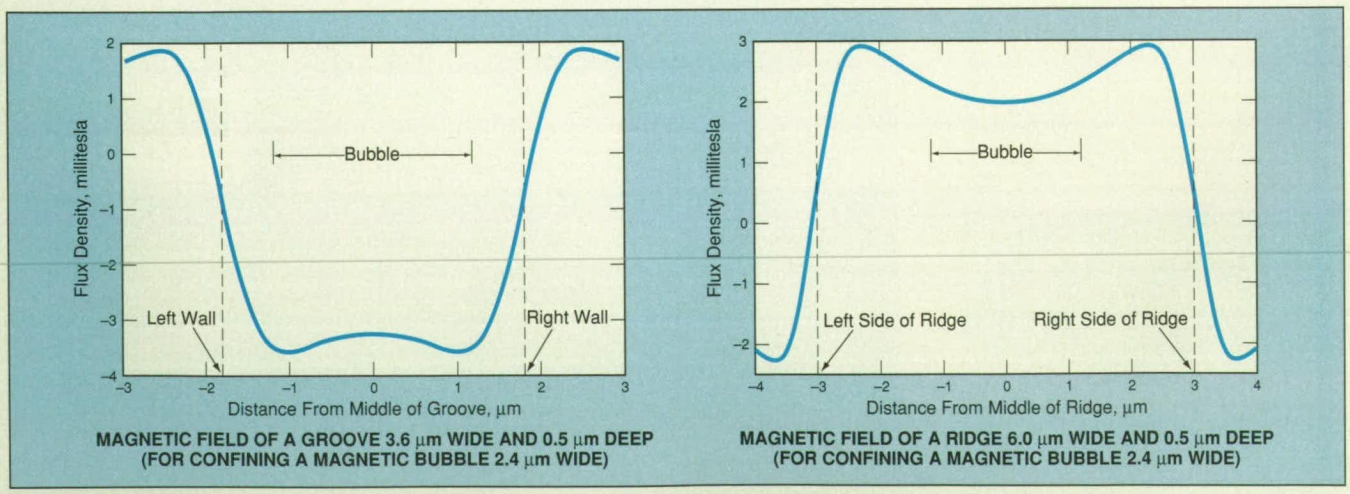
Refer to NPO-20232, volume and number of this NASA Tech Briefs *issue, and the page number.*

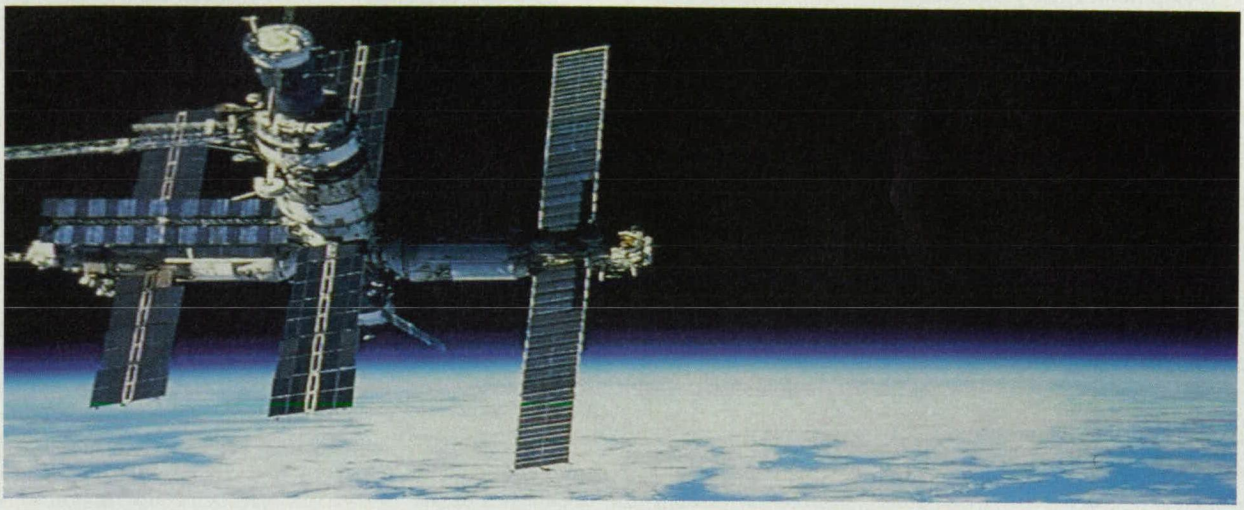


MAGNETIC FIELD OF A GROOVE 3.6 μm WIDE AND 0.5 μm DEEP (FOR CONFINING A MAGNETIC BUBBLE 2.4 μm WIDE)

MAGNETIC FIELD OF A RIDGE 6.0 μm WIDE AND 0.5 μm DEEP (FOR CONFINING A MAGNETIC BUBBLE 2.4 μm WIDE)

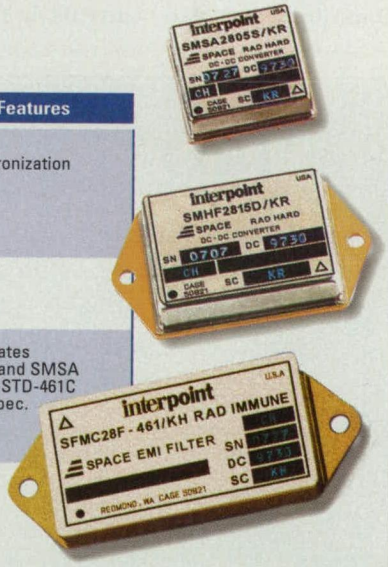
The **Cross-Track Variation in the Permanent Magnetic Field** of the garnet film is what determines the magnetic-bubble-confining properties of the track.

DC/DC Converters for Space Applications



Model	Output	Output (volts)	Size - inches (mm)	Screening Options	Features
Converter SMHF	Power 15 Watts	3.3, 5, 12 or 15 single 12 or 15 dual	1.460 x 1.130 x 0.330 (37.08 x 28.70 x 8.38) Flanged (shown) 2.005 x 1.130 x 0.330 (50.93 x 28.70 x 8.38)	Class H* or K* Rad hard - 3 levels	Inhibit Synchronization
Converter SMSA	Power 5 Watts	5, 12 or 15 single 12 or 15 dual	1.075 x 10.75 x 0.270 (27.31 x 27.31 x 6.86)	Class H* or K* Rad hard - 3 levels	Inhibit
Filter SFMC	Throughput Current 2.7 Amps	———	2.110 x 1.115 x 0.400 (53.59 x 28.32 x 10.16) Flanged (shown) 2.910 x 1.115 x 0.400 (73.91 x 28.32 x 10.16)	Class H* or K* Rad hard - 2 levels	Attenuates SMHF and SMSA to MIL-STD-461C CE03 spec.

* Per MIL-PRF-38534



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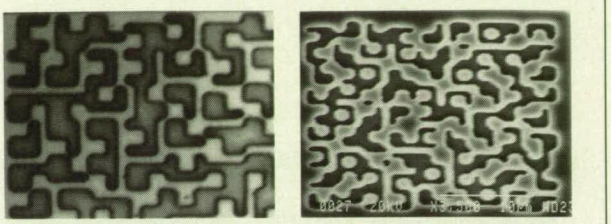
Bound-to-Quasi-Bound QWIPs With Random Reflectors

Dark currents are reduced and light-coupling efficiencies increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

Quantum-well infrared photodetectors (QWIPs) that are designed to exploit transitions between bound and quasi-bound electron quantum states and that incorporate random reflectors are undergoing development. Focal-plane arrays of such detectors are also undergoing development, all as part of a continuing effort to increase the responsivities and decrease the noise levels (dark currents) of infrared-imaging devices operating at wavelengths from about 3 to about 18 μm.

QWIPs have been discussed in numerous prior articles in *NASA Tech Briefs*. Two articles with particular relevance to the present devices were "Bound-to-Quasi-Bound Quantum-Well Infrared Photodetectors" (NPO-19633), Vol. 22, No. 9 (September 1998), page 54 and "Demonstration of 15 μm 128 × 128 Quantum Well IR Photodetector Imaging Camera" (NPO-19407) Vol. 20, No. 11 (November 1996), page 30. The first-mentioned article discussed, in some detail, the advantage of designing QWIPs to exploit bound-to-quasi-bound transitions to reduce dark currents below those achievable in QWIPs that exploit bound-to-continuum transitions. The second-mentioned article included a passing mention of the use of random reflectors to increase the efficiency of coupling of light into the QWIPs. In the time since the second-mentioned article, more information on the random reflectors has become available, and is presented below.



RANDOM REFLECTOR ON ONE PIXEL OF A 128-by-128 ARRAY WITH A CUTOFF WAVELENGTH OF 15 μm

RANDOM REFLECTOR ON ONE PIXEL OF A 256-by-256 ARRAY WITH A CUTOFF WAVELENGTH OF 9 μm

Each of These Random Reflectors was fabricated on one pixel of a focal-plane array of QWIPs. In the one on the left, the minimum feature size is 1.25 μm; in the one on the right, the minimum feature size is 0.6 μm.

The light-coupling problem was discussed in yet another prior article; namely, "Cross-Grating Coupling for Focal-Plane Arrays of QWIPs" (NPO-19657), *NASA Tech Briefs*, Vol. 22, No. 1 (January 1998), page 6a. To recapitulate: (1) The direction through the thicknesses of the quantum wells is parallel to the focal plane; (2) Quantum selection rules allow the detection of only that part of the incident light that is electrically polarized along the direction through the thicknesses of the quantum wells and thus perpendicular to the focal plane; and (3) The light to be detected is incident along directions approximately perpendicular to the focal plane, and thus only a small fraction of it is electrically polarized along the thicknesses of the quantum wells. Prior to the development of the random reflectors, light-coupling efficiency was increased by illuminating QWIPs via facets

inclined 45° to the directions through the thicknesses of their quantum wells. However, the 45° coupling scheme is not suitable for two-dimensional imaging arrays of QWIPs. The random-reflector scheme is suitable for two-dimensional arrays.

Many more passes of infrared light inside a QWIP, with a corresponding increase in responsivity over that achievable with a 45° facet, can be obtained by incorporating a randomly roughened reflecting surface on top of the QWIP. The random structure of the reflector prevents the light from being diffracted perpendicularly backward after the second bounce, as happens in the case of a cross-grating coupling like that discussed in the third-mentioned prior article. After each bounce, light is scattered at a different random angle, and the only chance for light to escape from the detector occurs when it is reflected toward the surface within the critical angle of the perpendicular. For a GaAs/air interface, this angle is about 17°, defining a very narrow escape cone for the trapped light.

The QWIP in each pixel of an array according to the present design concept contains a random reflector (see figure) with scattering surfaces at two levels separated by a quarter of the wavelength of interest in GaAs. The area of the top (unetched) level equals the area of the bottom (etched) level. The combination of equal areas and quarter-wavelength separation maximizes the destructive interference of light reflected from the two levels along the perpendicular, thus limiting the leakage of light through the escape cone. This random reflector structure can be fabricated by use of standard photolithography and selective dry etching with CCl_2F_2. The advantage of photolithography over a completely random fabrication process is the ability to accurately control the sizes of features to preserve pixel-to-pixel uniformity.

This work was done by Sarath Gunapala, John K. Liu, Mani Sundaram, and Jin S. Park of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Components and Circuits category.*

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Refer to NPO-19815, volume and number of this NASA Tech Briefs *issue, and the page number.*

Update on the Web Interface for Telescience

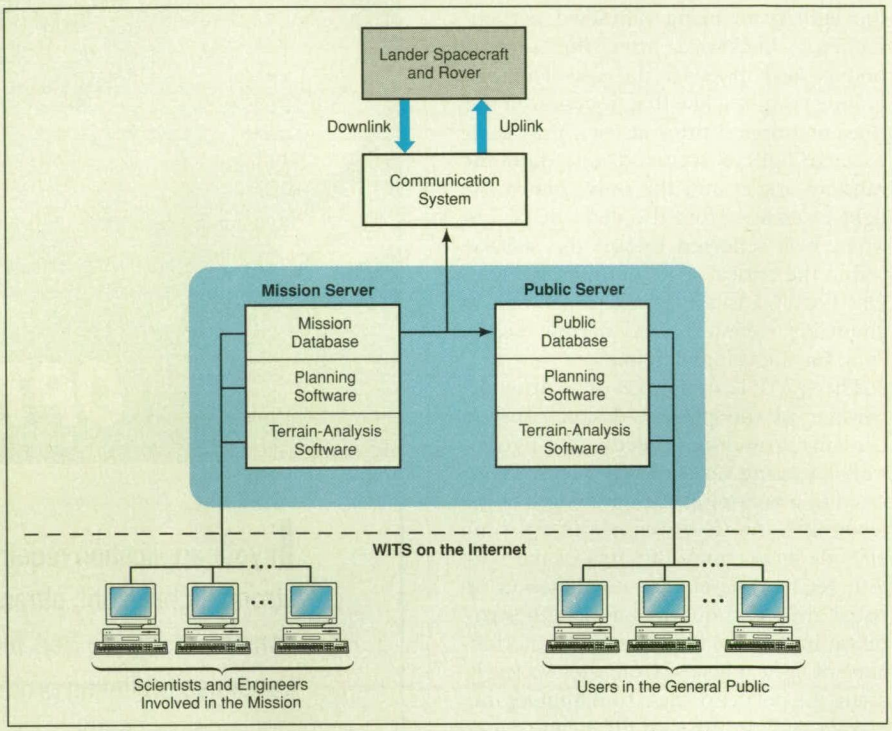
The interface software is automatically downloaded by use of web-browser software.

NASA's Jet Propulsion Laboratory, Pasadena, California

An Internet-based software system, called the "Web Interface for Telescience" (WITS), enables geographically dispersed scientists to participate in scientific exploration of remote planets by use of instrumented landers and robotic vehicles called "rovers." WITS at a previous stage of development was described in "Web Interface for Telescience" (NPO-19934), *NASA Tech Briefs*, Vol. 21, No. 8 (August 1997), page 34. Since that description was published, major additional features have been incorporated. Originally intended for use in a rover mission on Mars in the year 2001, WITS reached sufficient maturity early enough to have limited use during the 1997 Mars Pathfinder mission. Also, WITS will be used in the 1998 Mars Polar Lander mission.

One basic purpose of WITS is to enable mission scientists at their home institutions to collaborate, quickly and efficiently, in planning planetary robot operations without having to travel to a central control station at NASA's Jet Propulsion Laboratory. This is accomplished by use of interactive displays of images of terrain from rover-mounted video cameras, terrain maps derived from such images, and other data from rover-mounted instruments. Provisions for measuring and annotating terrain features and planning mission activities are included in the displays. Scientists and engineers can, for example, use WITS displays to enter such command data as way points on a traversal of terrain, plus scientific observations and/or engineering tasks that the rover must perform at some or all way points.

Another basic purpose served by WITS is to communicate mission data to the public as quickly as possible. To serve this purpose while providing an element of security, WITS is constructed as two physically separate, parallel systems: the mission system and the public system (see figure). Both systems receive data updates from the rover mission, and both systems contain the same software, including software for planning rover tasks. However, only the mission system commands the rover. The planning software in the public system can be used only to perform simulations that reside solely on users' computers. In other words, the mission and public systems are nearly identical, except that data are not transmitted from the public to the mission system.



Geographically Dispersed Computer Users have access to rover-mission data, though only scientists and engineers directly involved in the mission can affect the mission. Members of the general public can use planning software to plan and simulate rover activities on their local computers only.

The WITS software is divided into two parts: (1) the client part, which is executed on a user's computer, and (2) the server part, which is executed on one server computer for the mission system and on another server computer for the public system. The servers communicate with the clients and perform such computationally intensive operations as processing of stereoscopic images and generation of range maps. The mission server also acts as an interface with the communication system that conveys data to and from the rover and its spacecraft. The servers maintain a common data base, including information on the current mission plan. Collaboration is greatly facilitated in that the same video images, instrument readouts, and planning information can be viewed simultaneously by all users. However only mission participants (who must prove authorization by logging onto the mission server by use of passwords) can modify the common data base.

The client part of the WITS software is written in the Java computing language as a Java applet and is automatically downloaded onto the user's computer by the user's own web-browser software. This feature makes WITS available to many users and executable on almost any computer at any site. The great advantages of this feature are that the collaborating team and public audience can be expanded at little cost, and that each user has immediate access to the most recent version of the client part of the WITS software.

This work was done by Paul Backes of Caltech and Kam S. Tso and Greg Tharp of IA Tech, Inc., for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*

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Casting the Future

Eight-Channel WDM Fiber-Optic Data-Communication System

Each channel would carry data at a rate up to 2.5 Gb/s.

John F. Kennedy Space Center, Florida

A proposed wavelength-division-multiplexing (WDM) optical communication system would feature a single optical fiber carrying eight channels of digital data signals. In the original application, the signal in each channel would be a serial digital video-camera output, but the system could just as well be used to convey other serial data streams. The data rate in each channel could be as high as 2.5 Gb/s.

The center wavelengths in the eight channels would range from 1,535.04 to 1,557.37 nm, and are chosen to obtain an interval of 400 GHz between the center frequencies of adjacent channels. The transmitter for each channel would be a distributed-feedback laser with a modulation frequency band of 50 kHz to 2.5 GHz. Each transmitter would accept input data signals at the emitter-coupled-logic (ECL) level. Because the laser transmitters would be subject to thermal wavelength drift, a feedback-controlled thermoelectric cooler would be used to maintain constant temperature and thereby prevent the middle frequency of the laser of each channel from drifting into the adjacent channel. The channel separation of 400 GHz would provide a margin against any drift due to a harsh environment, such as the space shuttle launch pads.

The optical fiber would be of the single-mode type. The outputs of the transmitters would be wavelength-multiplexed and coupled into the optical fiber by one of several alternative devices: a simple power coupler, a diffraction-grating-based coupler, an arrayed waveguide grating, or an interference-filter-based coupler. In choosing one of these devices for a specific application, one would have to consider the following characteristics, among others: A diffraction-grating-based coupler would offer minimum insertion loss for each channel, but would be less thermally stable than an interference-filter-based coupler would be. On the other hand, in an interference-filter-based coupler, the insertion loss in each successive channel would be additive.

At the receiving end of the optical fiber, the signals would be wavelength-demultiplexed. With the exception of the simple power coupler, any of the three wavelength-multiplexing devices mentioned above could be used as the demultiplexer. The wavelength-demultiplexed optical signals would be fed to separate receivers for conversion to electrical data signals. The receivers would be capable of detecting infrared radiation at wavelengths from 1,200 to 1,600 nm. The electrical outputs of the receivers would be at the ECL level.

This work was done by William T. Toler of **Kennedy Space Center** *and Robert W. Swindle and F. Houston Galloway formerly of I-NET. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Electronic Systems category.*

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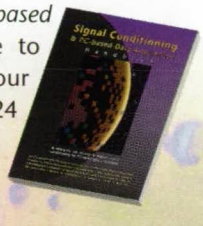

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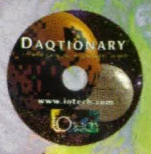

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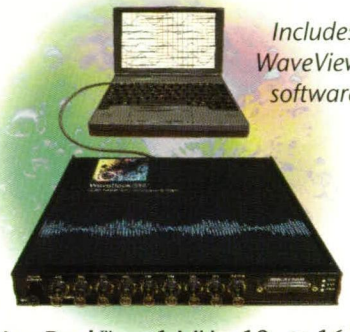

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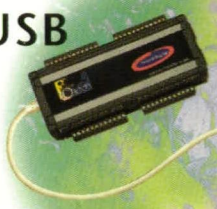

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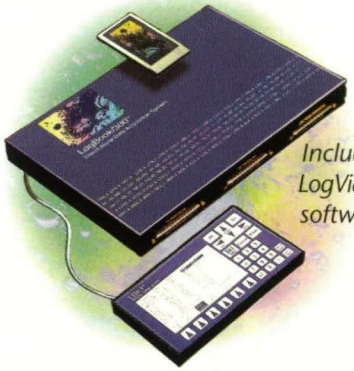

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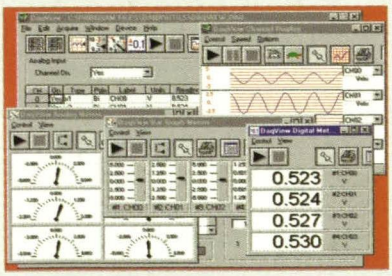

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Generic Graphical-User-Interface Program for FORTRAN Input

The NLEDIT computer program implements a generic graphical user interface for the preprocessing of FORTRAN namelist input files. The interface consists of a menu system, a message window, a help system, and data-entry forms. A form is generated for each namelist. The form includes an input field for each namelist variable along with a one-line description of that variable. Detailed help information, default values, and minimum and maximum allowable values can all be displayed via menu picks. Inputs are processed through a scientific-calculator program that provides for the use of complex equations instead of simple numerical inputs. A custom user interface is generated simply by entering information about the namelist input variables into an ASCII file. There is no need to learn a new graphics software system or programming language. NLEDIT can be used as a stand-alone program or as part of a larger graphical-user-interface program. Although NLEDIT is intended for files using namelist format, it can be easily modified to handle other file formats.

NLEDIT is customized for a particular application by use of a data-definition file. The data-definition file is an ASCII file that contains such information about such program inputs as the names, types, dimensions, default values, and limits of variables, plus help information. NLEDIT reads this information into a data base and then uses it to produce an appropriate interface. The user interface changes only in appearance for a particular data-definition file; no recompiling of code is necessary.

The NLEDIT Program is composed of three main modules: the calculator module, the data dictionary (or data base), and the graphics module. The calculator module is used to convert an equation, in the form of a character string, into a numerical value. The data dictionary allows the other modules to store and retrieve information about specific items defined in the data-definition file. The graphics module is the Motif code for displaying windows and processing input events.

NLEDIT is written in C language and has been successfully implemented on an SGI Indigo 2 computer under IRIX 5.3, an IBM RS/6000 computer running AIX v4, and a Sun Sparcstation computer under SunOS 4.1.3. This software package requires MIT's X Window System, Version 11, Revision 4 and OSF/Motif 1.1 or higher. A FORTRAN 77 compiler that supports namelist input is also required to compile the included sample FORTRAN program. The standard distribution medium for NLEDIT is a 0.25-in. (6.35-mm) streaming-magnetic-tape cartridge (Sun QIC-24) in UNIX tar format. Alternate distribution media are available upon request. An electronic copy of the documentation in PostScript format is included on the distribution medium. NLEDIT was released in 1995.

This program was written by B. P. Curlett of **Lewis Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Software category. LEW-16141*

Protective Anode Separators for Rechargeable Lithium Cells

These separators would help protect against internal short-circuiting in overdischarge.

NASA's Jet Propulsion Laboratory, Pasadena, California

The anode separators in rechargeable lithium-ion electrochemical cells that contain carbon lithium-intercalating anodes with copper current collectors would be modified, according to a proposal, to give some protection against the internal short-circuiting that tends to occur during overdischarge. The carbon anodes offer advantages of greater safety and chemical stability over anodes made of pure lithium, but they also introduce a need to limit discharge, as explained below. The modified anode separators would not obviate the need to limit discharge, but would help to retard or prevent internal short-circuiting when overdischarge occurs despite efforts to prevent it.

In a cell that contains a pure lithium anode, there is still plenty of lithium left in the anode, even during overdischarge. However, in a cell with a carbon anode, no more lithium is available from the anode once discharge is complete. Therefore, during overdischarge, lithium ions are not being intercalated into the cathode; instead, a new electrochemical cell is formed between the cathode and the copper current collector in the anode. As overdischarge proceeds, copper is dissolved from the anode current collector and travels through the pores in the cell separator toward the cathode. Eventually, the deposited copper forms an electrically conductive path between the anode and cathode; that is, a short circuit develops within the cell.

The proposed modification of the separator in a given cell must be tailored according to the nonuniformity of utilization of the carbon electrode and of the distribution of electric current between the cathode and anode. In other words, it is necessary to identify the location on the carbon electrode that is most likely to be susceptible to short-circuiting during overdischarge. In a prototype cell, this location is an anode tab. The essence of the proposed modification is to render nonporous the part of the anode separator bag that covers the tab, to prevent penetration by copper.

The figure illustrates how a modified separator bag for the prototype cell could be fabricated. The starting separator material would typically be a rectangular sheet of microporous polypropy-

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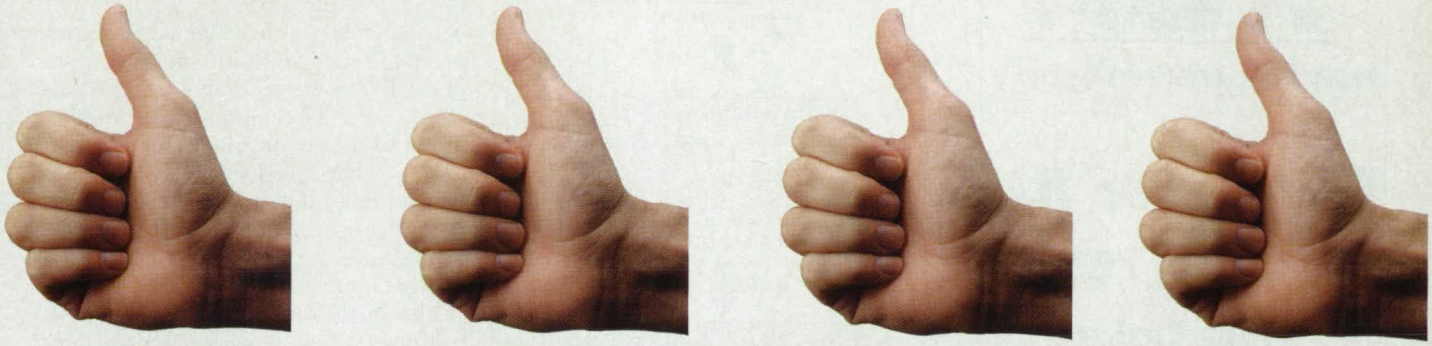

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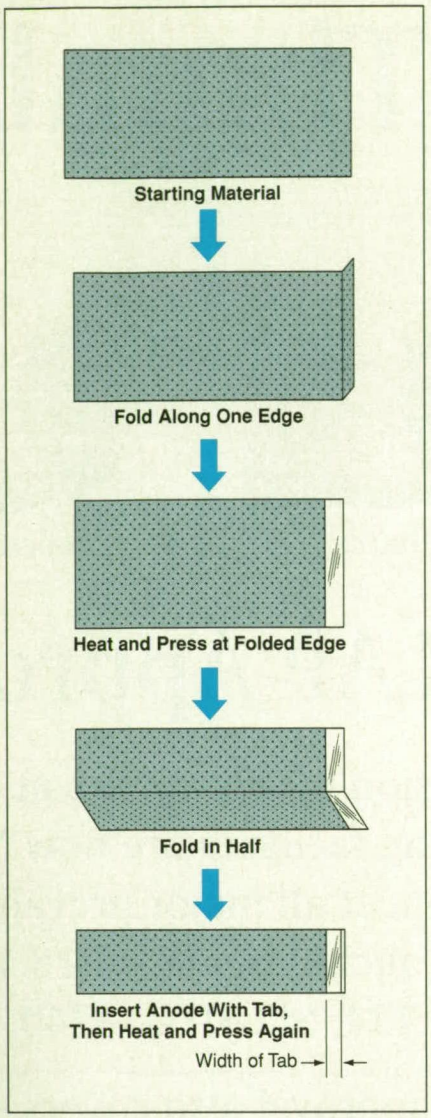

A Sheet of Porous Separator Material Would Be Formed into a separator bag with a nonporous, transparent edge in the tab region.

lene, which would be opaque because of its porosity. The sheet would be folded along one of the shorter edges, then pressed and heated to close the micropores. Upon closure of the micropores, the folded, pressed edge region would become transparent. The heating and pressing would also cause the two layers of the fold to merge into a single transparent layer. The reason for folding before heating and pressing is that a single layer of hot-pressed material could still contain holes that would allow penetration of copper, while a double layer has proved effective in preventing penetration of copper.

The sheet would be folded again — this time in half along its larger dimension to form a separator bag. The carbon anode could then be enclosed in the bag with the tab portion visible through the hot-pressed edge region.

This work was done by Chen-Kuo Huang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com*** *under the Materials category.*

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Refer to NPO-19950, volume and number of this NASA Tech Briefs *issue, and the page number.*

Microwave Brazing of Polycrystalline Diamond Onto Drill Bits

Temperatures would be controlled to achieve brazing without overheating.

NASA's Jet Propulsion Laboratory, Pasadena, California

A microwave-heating technique has been developed for making a braze joint (1) between a tungsten carbide support and a surface layer of polycrystalline diamond or, alternatively, (2) between a tungsten carbide support and a relatively thin tungsten carbide backing layer with polycrystalline diamond on its working surface. The technique would be used to fabricate diamond-covered cutting tool bits. Such bits could be used, for example, to drill geothermal wells and would be improved versions of some of the diamond-covered bits now used to drill oil and gas wells. Whereas the braze joints of the oil-and-gas-well versions become weakened at temperatures ≥ 700 °C, the braze joints of the improved drill bits would be designed to withstand hard-rock-drilling temperatures up to 900 °C.

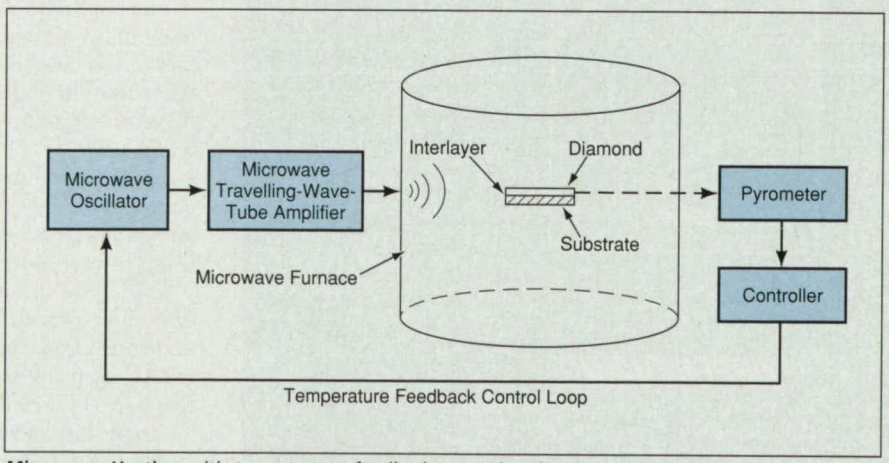
The major problem in fabricating the improved drill bits is to use higher-melting-temperature brazing materials and to heat the braze joints accordingly to effect brazing, without overheating the diamond. "Overheating" in this context means heating to a temperature

≥ 1,200 °C, causing the diamond to become graphitized and thereby to lose resistance to wear. The basic idea of this technique is to utilize the selective heating characteristics of microwaves to develop the required brazing temperature without overheating the diamond. Selective heating would be possible because the commercially fabricated diamond is a very good absorber of microwaves, while the proposed brazing materials would be moderate to good absorbers.

The proposed microwave-technique is related to microwave-heating techniques described in two prior articles in *NASA Tech Briefs*; "Selective Microwave Heating of Thin-Film Heterostructures" (NPO-19402), Vol. 21, No. 3 (March 1997), page 16a and "Microwave-Induced Combustion Synthesis of Ceramic/Metal Composites" (NPO-19637) Vol. 21, No. 5 (May 1997), page 26. The temperature of the layer of brazing material ("braze interlayer") in a given case would depend on the microwave energy absorbed, on conductive and radiative transfer of heat between this layer and the adjacent substrate and diamond layers, and on thermal radiation from the diamond surface layer to free space.

Experience teaches that the best capillary action and shear strengths in braze joints on diamond/tungsten carbide tool bits are achieved with fillets of 0.08 to 0.8 mm, and that braze interlayers should be thick enough (at least 0.02 mm) to relieve stresses caused by differential thermal expansion between diamond and tungsten carbide. The brazing material must be able, at the brazing temperature, to wet or diffuse into both the diamond surface layer and the tungsten carbide substrate or into the tungsten carbide backing layer and tungsten carbide substrate, as the case may be.

In preparation for a typical fabrication process according to this technique, a diamond disk 2 to 3 mm thick is placed on top of a braze interlayer 0.08 to 0.8 mm thick on top of a tungsten carbide substrate. This assembly of components is mounted in a region of strong electric field in a microwave processing chamber. A pyrometer is focused on the diamond surface layer; during the subsequent microwave heating, the output of the pyrometer is used to monitor the temperature of the diamond, and is used as a feedback signal to control the microwave power to achieve the desired brazing temperature. The dimensions of the braze interlayer, the components to



Microwave Heating with temperature feedback control makes it possible to braze polycrystalline diamond to an underlying layer of tungsten carbide, without overheating the diamond.

be brazed, and the process tooling are chosen, along with the temperature-vs.-time heating curve, to obtain the strongest possible braze joint with minimal residual stress from differential thermal expansion.

The braze interlayer could consist of a foil of a braze filler metal. Alternatively, the braze interlayer could be made of a combustion-synthesis compound, in which case microwave heating would be used to ignite a combustion wavefront with temperatures of thousands of degrees. When this wavefront reached the interfaces with the adjacent backing and substrate layers, it would provide sufficient local heating to form the desired braze joint.

This work was done by Martin Barmatz and Henry W. Jackson of Caltech and Robert P. Radtke of Technology International Inc. for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category.*

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Time-Dependent Nature of Adhesive EA946

Temperature and aging times affect the viscoelasticity of this adhesive.

Marshall Space Flight Center, Alabama

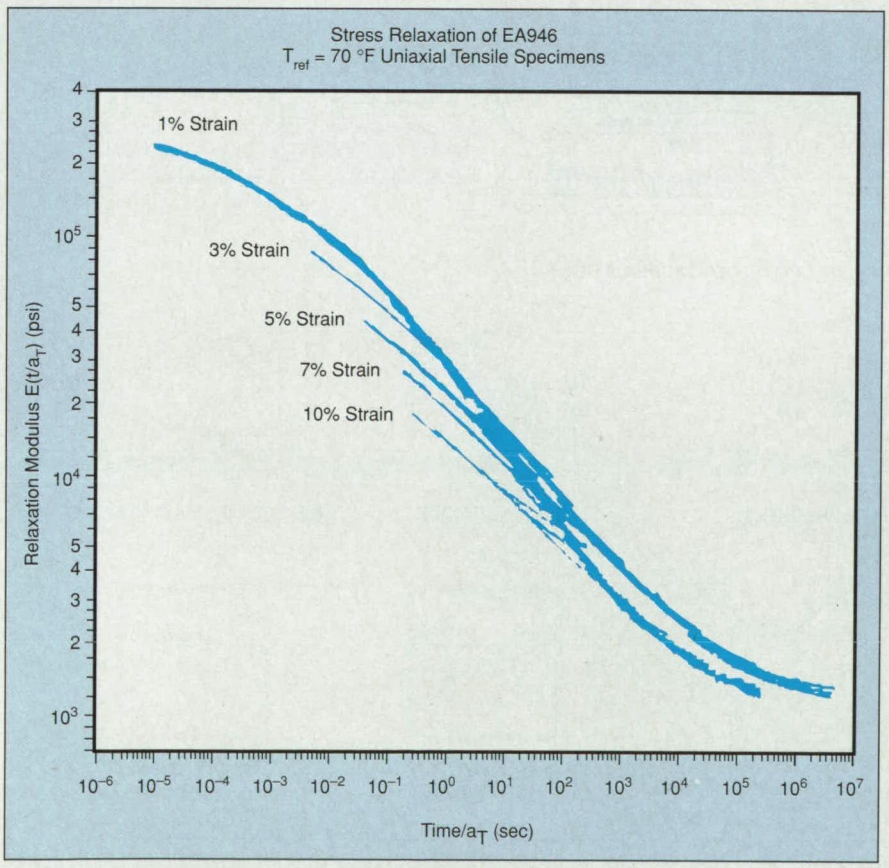
More accurate analyses of adhesive EA946 can now be accomplished using new mathematical models. Tests involving this adhesive (used in the space shuttle's reusable solid-rocket-motor nozzle and other rocket-motor nozzles) indicated that the adhesive is nonlinearly viscoelastic at short equivalent times and linearly viscoelastic at long equivalent times. These tests also showed that the material properties of EA946 change with aging time after cure.

The viscoelastic nature of EA946 was modeled using a strain-dependent time-shift factor. Aging effect with only a time-shift factor was also modeled. An assumption (from earlier test data) that the bulk modulus of this adhesive remains constant for all times and temperatures was used for these modeling investigations.

During previous testing of this adhesive, master stiffness curves at various strain levels were recorded. The curves were generated from stress-relaxation data at a given strain level, using several different temperatures.

The figure illustrates how stress-relaxation curves of 1, 3, 5, 7, and 10 percent were divergent for short equivalent times and convergent for long equivalent times. Aging time after the cure caused the trend differences between the 1-percent and the 3-, 5-, 7-, and 10-percent stress-relaxation data.

Strain-shift and aging factors were added to the testing to account for the nonlinearities and aging effects. The temperature-shift factor was also introduced into the model.



This mathematical model shows that **Stress Relaxation Curves** were divergent for short equivalent times and convergent for long equivalent times at 70 °F (21 °C).

After many attempts to model the material response of EA946 using a linear viscoelastic model, nonlinearities were introduced into the model. Shift factors that were a function of strain-level and time were used to evaluate the nonlinearities. This approach for evaluating the nonlinearity of adhesive EA946 accounted for the strain-level dependence of uniaxial tests (as noted in the illustration).

Tests showed the material properties of EA946 to be sensitive to the effects of age-time after cure. A series of additional aging tests conducted at 0 day, 1 day, and 3, 5, 10, 60, 90, and 365 days indicated that the elastic modulus increased 110 percent with 90-day aging and 370 percent with one-year aging. The ultimate strain decreased by approximately 75 percent, while the strength of the bulk adhesive did not appear to increase. Additionally, the bondline strength increased by approximately 25 percent during one year of aging.

This work was done by David E. Richardson and Russell A. Crook of the Thiokol Corporation for **Marshall Space Flight Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Materials category. MFS-31161*

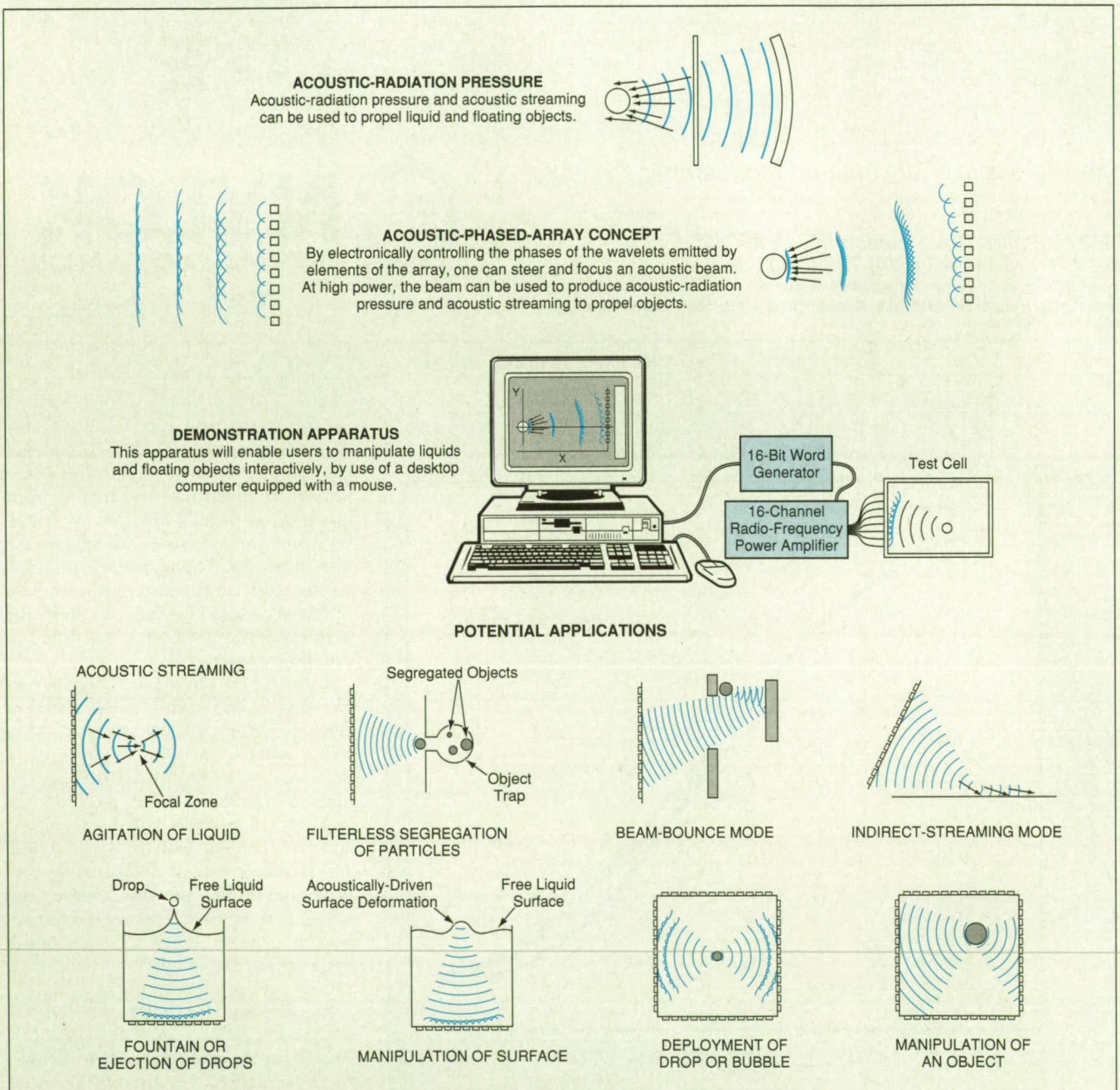
Manipulation of Liquids by Use of Sound: Part I

Liquids and objects suspended in liquids could be manipulated nonintrusively.

Lewis Research Center, Cleveland, Ohio

An acoustic-radiation-pressure phased array (ARPPA) is undergoing development at Lewis Research Center. ARPPAs are envisioned as general-purpose, nonintrusive tools for manipulating both liquids and objects suspended in liquids.

Acoustic-radiation pressure and acoustic streaming are effects created by high-intensity sound. Acoustic-radiation pressure applies forces to objects situated on acoustic paths. Acoustic streaming is a unidirectional flow that can arise because



The **Acoustic-Phased-Array Concept**, similar to the concept of phased-array antennas for electromagnetic waves, involves the exploitation of collective effects of waves emitted by elements of an array. Here, acoustic (instead of electromagnetic) beams are steered and focused by controlling the phases of excitations applied to the elements of the array.

sound can exert a thrust on a liquid in which it propagates. ARPPAs would make it possible to exploit acoustic-radiation pressure and acoustic streaming (see figure) to perform such manipulation and control functions as propelling or agitating liquids, moving floating objects, controlling the shapes of liquid surfaces, or ejecting liquid drops.

A beam of sound can be produced by use of an array of acoustic transducer elements. Each element emits small wavelets of sound that, over a distance, overlap other wavelets. Wavelets that are in phase tend to coalesce into a single beam. If the wavelets are focused, then their amplitudes become superimposed to form a beam of high intensity. The distinguishing feature of an ARPPA is that one can electronically control the phase relationships among the elements of the array to steer the beam and adjust the size and shape of the focal region. Thus, one can adjust the position and shape of the region where acoustic-radiation pressure and acoustic streaming occur.

An interactive-computer-controlled ARPPA demonstration apparatus is under construction. This apparatus is designed to enable a user to interactively control the focus and position of an acoustic-radiation-pressure beam. The apparatus is expected to aid in the development of specific users' applications.

An ARPPA enables a user to exert some control over a liquid without intruding into its container. ARPPAs might be capable of performing the functions of such other mechanical devices as agitators, filters, probes, and manipulators. The ARPPA approach holds promise for simplifying systems by reducing the need for external plumbing and intrusive mechanisms and for such high-maintenance items as seals and bearings.

Potential uses for ARPPAs include the following:

- Agitation of Liquids: ARPPAs could provide the agitation needed for processes that involve liquids in sealed systems. ARPPAs could be used to disperse accumulations of particles, and to form and maintain such suspensions as slurries, paints, and pastes. Furthermore, agitation of liquids by use of acoustic-radiation pressure could be used to obliterate thermal gradients or concentration gradients and thereby prevent stratification of chemicals in vessels.
- Segregation of Gas Bubbles and Solids Suspended in Liquids: ARPPAs might be useful for segregating objects suspended in liquids in sealed systems, without using filters. Acoustic-radiation pressure could be used to force contaminant bubbles and particles into traps, where they could be rendered harmless without breaking into the system. The elimination of in-line filters would reduce probabilities of clogging and reduce the amount of maintenance needed, and could thus also be useful in reducing the risk of contamination of the environment from systems that process toxic chemicals.
- Ejection of Liquid Drops: If droplets could be ejected from a pool of liquid without using a nozzle, then there would be no risk of clogging. Therefore, suspended particles would not hinder operation. By use of acoustic-radiation pressure with precise focus combined with tone-burst control, one could eject drops on demand, with precise control of sizes and velocities of the drops. One could use acoustic-radiation pressure in this way to dispense picoliter volumes of liquids on demand, to apply paints or other liquid coating materials without using masks, or to apply molten metals (e.g., solder in automated soldering of circuit boards).
- Manipulation of Free Surfaces: ARPPAs could be used to control surface waves for such purposes as suppression of sloshing or of standing waves in tanks. Surfaces could be manipulated to control wetting through selective forcing of

liquids into contact with solid surfaces. Solder fountains driven by acoustic-radiation pressure might be useful as means to refine the common wave-soldering method used to solder electronic-circuit boards. ARPPAs could also be used to drive surface waves on liquids for the selective application of adhesive and other coating materials.

- Manipulation of Immersed Objects: ARPPAs could be used to manipulate such immersed objects as bubbles, drops of immiscible liquids, or partially buoyant solid objects. The focusable, steerable nature of ARPPAs could be used to move such objects though complex paths and even to oppose such forces as those associated with gravitation, fluid currents, and electromagnetic fields. ARPPAs could be employed to orient and concentrate fibers and other reinforcing constituents to be cast in composite structures. In outer space, ARPPAs could control the ingestion of gas bubbles into tanks containing liquids. ARPPAs might be useful for micromanipulation of biological tissues in liquid media. ARPPAs might even be proven suitable for nonintrusive repositioning of detached retinas in human eyes.

This work was done by Richard C. Oeftering of **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16470.

Manipulation of Liquids by Use of Sound: Part II

Drops and bubbles could be controlled with minimal equipment.

Lewis Research Center, Cleveland, Ohio

Acoustic-radiation pressure can be used to improve performance in the dispensing of liquid drops into gases or vacuum and in dispensing gas bubbles into liquids. In a typical application involving dispensing a liquid, this is accomplished by use of a high-frequency, high-intensity acoustic transducer coupled with a conventional syringe and hollow dispensing needle (similar to a hypodermic needle). A small dose of liquid passes through the needle and forms a drop at the tip. The drop is held in place by surface tension. The acoustic transducer emits a premetered acoustic tone burst at high power. The bore of the needle conducts the acoustic waves to the drop, where acoustic-radiation pressure creates a force on the droplet. When the burst of force is sufficient to overcome surface tension, the drop separates from the tip.

Unlike in previous approaches to dispensing, it is not necessary to rely on gravitation or on the inertia of drops to cause deployment. Usually, the sizes of drops are proportional to the sizes of needles, but by use of acoustic-radiation pressure, one can deploy drops independently of needle sizes. Because deployment by acoustic-radiation pressure is controlled electronically, it is possible to adjust the acoustic excitation to deploy or dispense drops of various liquids and various sizes with various initial velocities, on command.

In a given apparatus, acoustic waves can be coupled from a transducer in any of several schemes. Examples (see figure) include (1) using the fluid in the bore of the needle as a waveguide to conduct acoustic power to the drop at the tip of the needle; (2) using an external coaxial transducer mounted at the base of the needle and focused at a bubble at the tip of the needle; (3) using the cylindrical wall of the needle as a solid waveguide to conduct the acoustic waves from transducer to the drop at the tip; or (4) using an external coaxial transducer mounted away from the needle and focused at a bubble at the tip. The fourth-mentioned scheme is suitable for the case in which a bubble does not stick to the needle; the acoustic transducer in this scheme emits an opposing acoustic beam that pins the bubble in place until it is time to release the bubble on command. All of the foregoing schemes can be used individually or in combination.

Acoustic transducers can also be used as sensors. One can exploit this sensory capability to measure positions of drops and bubbles. By monitoring the electrical signal from a transducer, one can verify deployment of a drop or bubble, without visual monitoring of the drop or bubble.

Potential applications in which one could use acoustic-radiation pressure to enhance dispensing of drops and bubbles include the following:

- Outer-Space Applications: Specific applications include fluid-physics, drop-physics, and droplet-combustion experiments; containerless processing; and dispensing liquids in a variety of systems in which premetered drops are needed.
- Terrestrial Applications: The behaviors of drops and bubbles could be controlled while using fewer mechanical parts and less plumbing than are now needed for such purposes. Such control could be exploited for precise placement of paints, dyes, adhesives, liquid coating materials in general, pastes (including slurry pastes), and molten solders used in manufacturing. In many applications, this acoustic-radiation-pressure approach could eliminate the need for masks and related tooling and processing. This approach can also be followed in precise dispensing of drops and bubbles in chemical processes and in medical applications.

This work was done by Richard C. Oeftering of **Lewis Research Center.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Mechanics category.*

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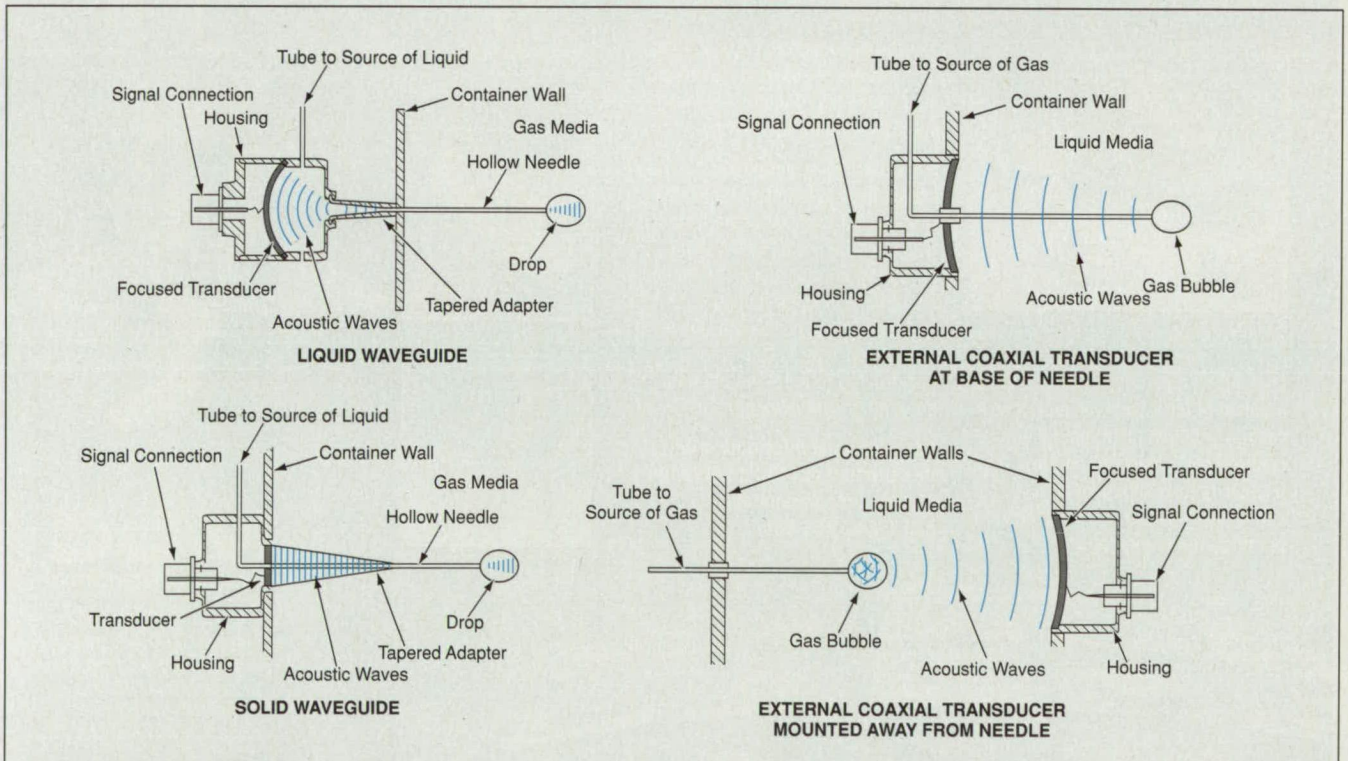


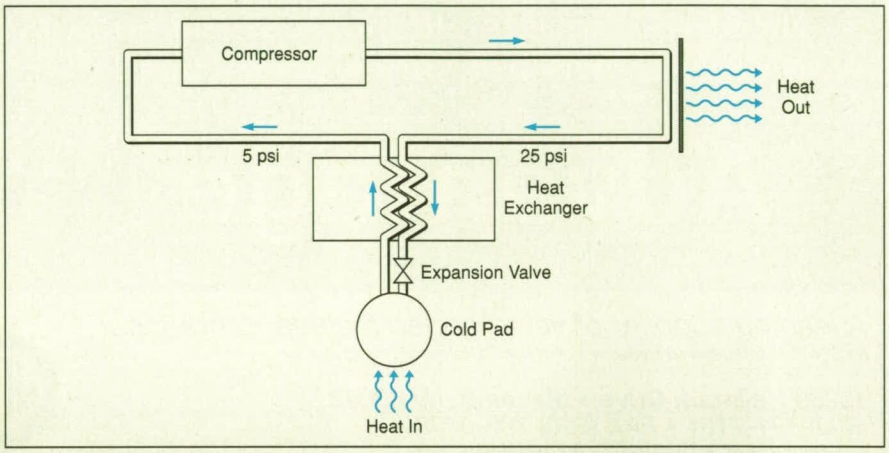
These Are Examples of Schemes for coupling acoustic waves from a transducer to a liquid drop or a bubble to be dispensed from the tip of a hollow needle.

Miniature Joule-Thomson Rankine-Cycle Refrigerators

A two-stage refrigerator should be able to cool from 313 to 70 K.

NASA's Jet Propulsion Laboratory, Pasadena, California

Miniature, lightweight, low-power, low-vibration Joule-Thomson Rankine-Cycle refrigerators have been proposed for cooling portable scientific instruments. These refrigerators would be made largely from silicon wafers by micromachining techniques like those used to fabricate integrated circuits. The compressors in these refrigerators would be microperistaltic pumps, in which voltages applied in spatial and temporal sequences to multiple electrodes positioned along channels would give rise to waves of electrostatic attraction that would cause membranes to pinch the channels closed at intervals in peristalsislike waves. [A fuller description of microperistaltic pumps was presented in "Microscopic Heat Ex-



Schematically, a Single-Stage Refrigerator of the proposed type would look like an ordinary typical vapor-compression refrigerator. However, it would be fabricated in miniature, with a microperistaltic pump as its compressor. The working fluid would be a mixture of gases chosen for Joule-Thomson-cooling capability.

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changers, Valves, Pumps, and Flowmeters" (NPO-19093), *NASA Tech Briefs*, Vol. 22, No. 7 (July 1998), page 66.]

A single- or multiple-stage refrigerator according to this concept could be made from two fused wafers. The figure schematically illustrates a single-stage refrigerator, in which a microperistaltic pump would compress the working fluid (a mixture of gases as described below) from a lower pressure of 5 psi (34 kPa) to a higher pressure of 25 psi (170 kPa). The compressed fluid would flow along a microchannel, where it would be partly cooled by transfer of heat into the surrounding wafer material. Continuing along its flow path, the compressed fluid would be cooled further and condensed in the first of two microchannels in a highly thermally conductive counter-flow heat exchanger within the wafer. After leaving the heat exchanger, the fluid would flow along a microchannel to an expansion nozzle in a cold pad that is thermally well insulated except for contact with the object to be cooled.

Upon expansion in the nozzle, the fluid would evaporate, drawing latent heat of vaporization from the cold pad. The vapor would flow into the second microchannel in the heat exchanger, where it would absorb heat from the compressed fluid in the first microchannel. Upon emerging from the heat exchanger, the fluid would return to the lower-pressure port of the microperistaltic pump, completing the cycle.

The Joule-Thomson-cooling capabilities of a number of gas mixtures have been studied to assess their utility as working fluids for a refrigeration cycle between an exhaust temperature of 200 K and a refrigeration temperature of 70 K. One suitable fluid was found that consisted of nitrogen and five hydrocarbons. With a mass flow rate of 0.001 mole/second and a heat-exchange efficiency of 0.98, the refrigerator could handle a maximum heat load of 0.3 W while maintaining a temperature of 71 K.

For most terrestrial applications, it would be more practical to exhaust heat at a higher temperature, giving rise to the need for two stages of refrigeration to reach a low temperature of 70 K. For example, the first stage could exhaust heat at 313 K and provide cooling at 190 K, while the second stage would be like the single-stage refrigerator described above, with its exhaust heat removed by the cold pad of the first stage. The composition of a suitable working fluid for the first stage consisted of carbon tetrafluoride and miscellaneous hydrocarbons. With a mass flow rate of 0.001 mole/second and a heat-exchange efficiency of 0.98, the first stage could handle a heat load of 2 W while maintaining a temperature of 190 K.

This work was done by Frank T. Hartley and Jack A. Jones of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Machinery/Automation category.*

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Microgravity Fiber-Pulling Apparatus

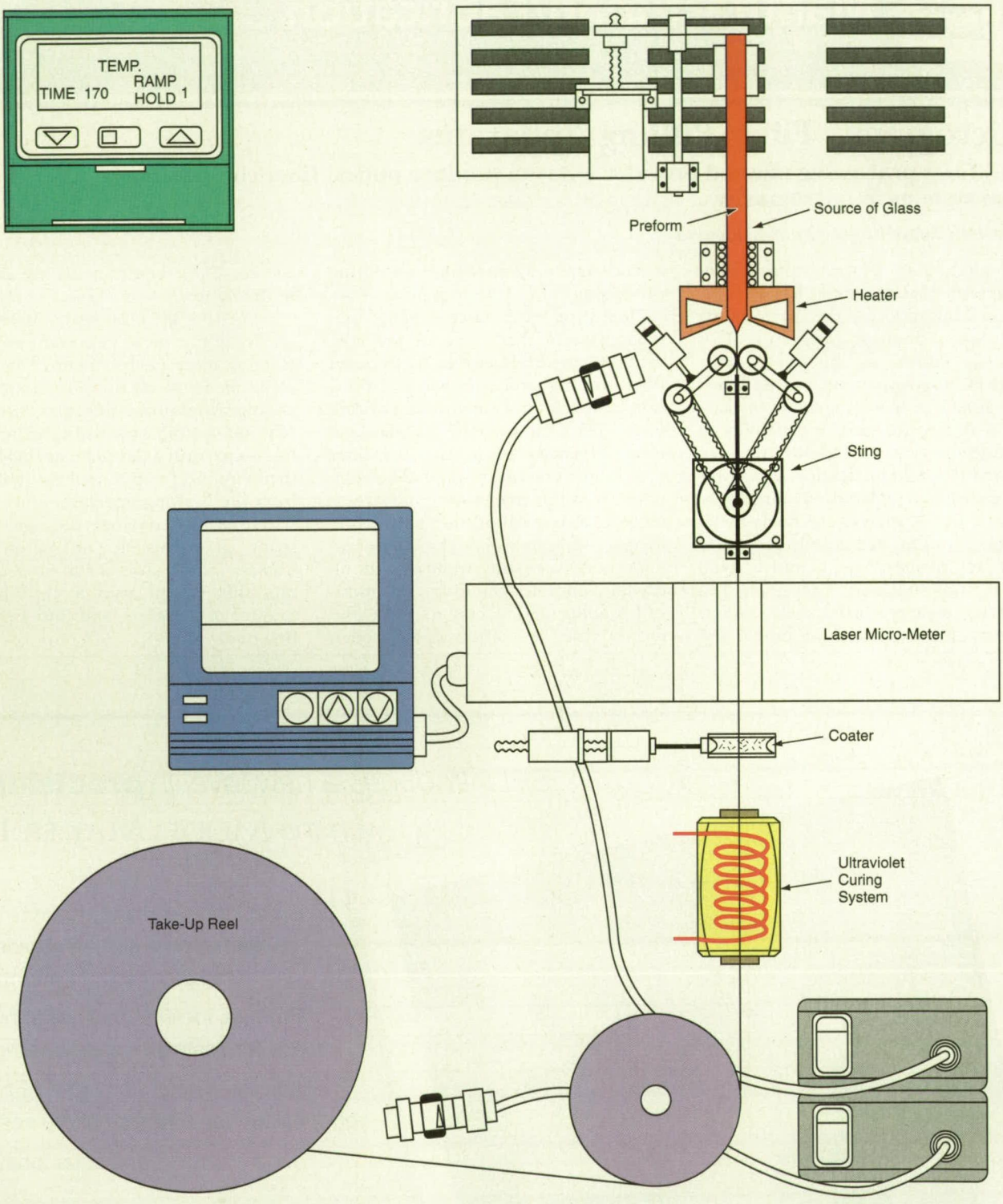
This fiber-processing method provides a way to produce optical fiber composed of glass systems in microgravity.

Marshall Space Flight Center, Alabama

A method to process optical fiber composed of glass systems has been developed in support of the space shuttle and Space Station programs. This process, known as the Microgravity Fiber-Pulling Apparatus, was designed to operate in a microgravity environment. It has the unique capability to produce heavy-metal glasses through the reduction of nucleation and allows low viscosity to be handled more easily. Optical fibers, such as the heavy-metal fluoride glasses, are usually very difficult to process in ground-based operations because the glass has inherent characteristics such as low viscosity, a narrow working range, and a tendency to form crystallites during processing.

Operation in microgravity has demonstrated that some of the conventional methods used in Earth-based fiber-forming processes will not function properly in a weightless environment. For example, the gravitational force necessary to initiate the fiber draw is not present in space. The components of this fiber-pulling apparatus include a source of the glass (preform), a sting to initiate the fiber-drawing process, a coating applicator for ultraviolet-curable cladding, an ultraviolet lamp, and a reel to place the drawn fiber on after it has been cooled. These components are shown in the figure.

Processing the glass system in microgravity is the most important step to forming more perfect fiber composed of the heavy-metal fluoride glasses. In microgravity, processing glass systems requires a sting (consisting of a platinum wire with a flat plate or fingers at the extremity) to pull molten glass out from the drawing aperture. Since current drawing chambers designed for space platforms do not allow extremely large volumes for fiber drawing, this design uses a chill block to quench the glass melt into a solidified fiber.



Components of the **Microgravity Fiber-Pulling Apparatus** include a source of glass (the preform), a sting to initiate the fiber-drawing process, a coating device, an ultraviolet curing system, and a take-up reel to place the fiber on after it has cooled.

Another drawback to conventional methods of processing fiber is the coating applicator, which needs to be completely contained and have the ability to operate through a fluid-transfer line to provide uniform cladding on the fiber. A syringe-type or peristaltic pump provides this apparatus with the appropriate capacity and pressure.

This work was done by Dennis Tucker of **Marshall Space Flight Center** *and Gary Workman and Guy A. Smith of the University of Alabama in Huntsville. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Manufacturing/Fabrication category.*
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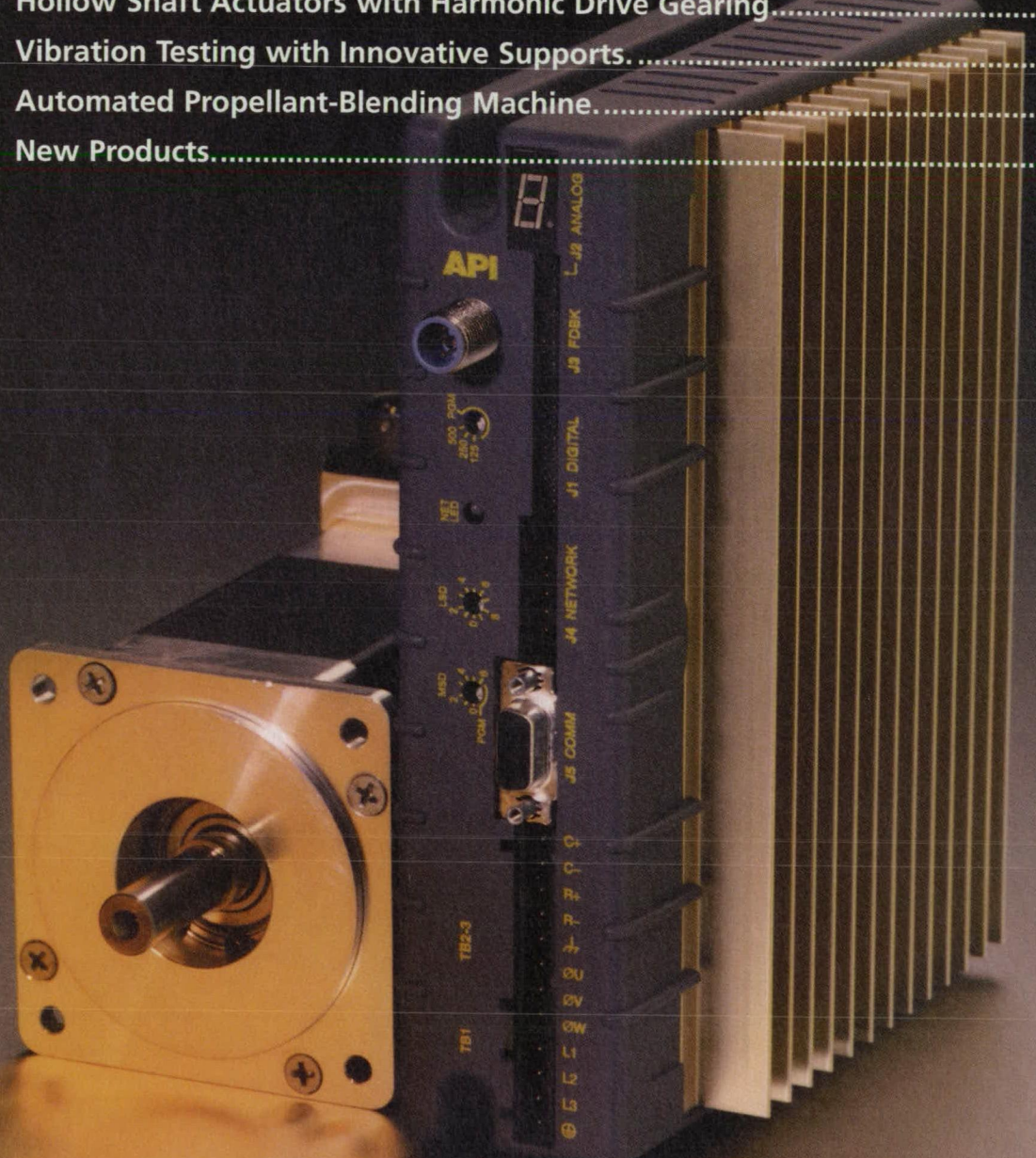

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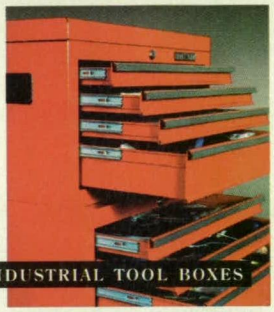
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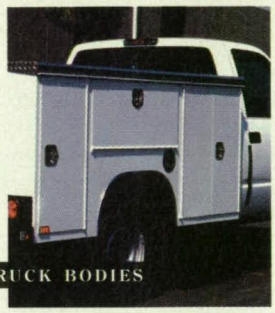
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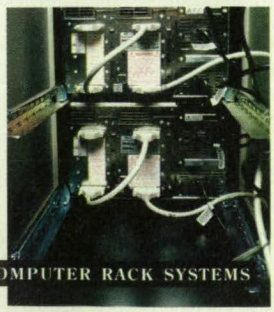
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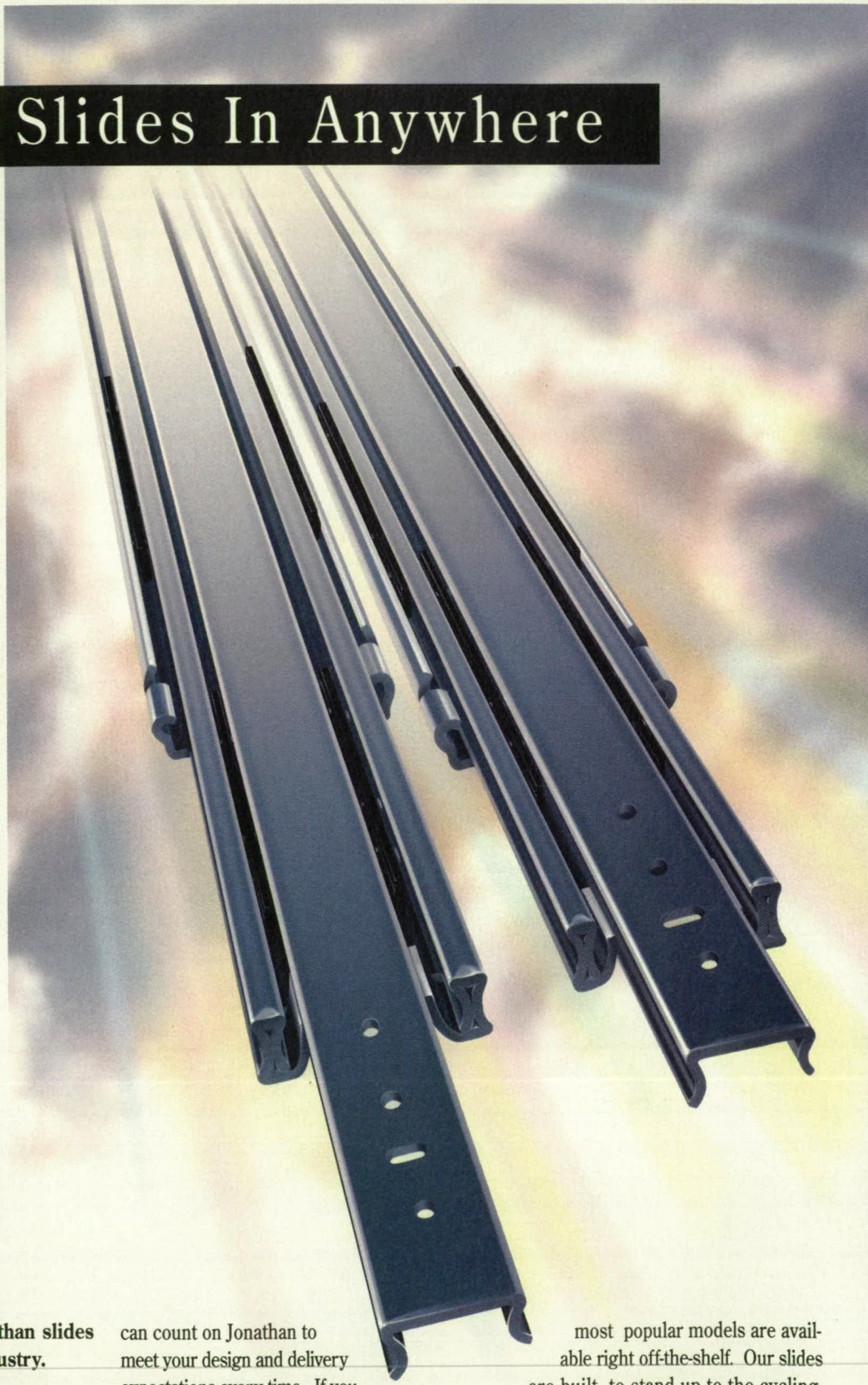

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A graphic method makes choosing hydraulic proportional control valves a snap.

The term "electrohydraulics" often conjures up visions of complicated servo systems full of wires and electronics. Though true in some cases, there is another area of electrohydraulic application that doesn't require a mass of circuitry for operation. Many conventional hydraulic systems suffer from shock and vibration due to the rapid shift time of on/off directional control valves. These sudden energy transfers are responsible for noise and leaks at a minimum—and serious machine damage at worst.

By applying open-loop proportional valves (electrohydraulics without complicated servo electronics) in place of on/off directional valves, these shocks and bangs can be eliminated. The result is longer-lasting machinery and a reduction in leaks and maintenance costs. Replacing the on/off valve is not complicated once the proper valve is selected. The "trick" is selecting the right valve. To facilitate the selection, this article presents a graphic method for determining the valve requirements. The concept used is that the area under a velocity vs. time plot is equal to the distance traveled (Calculus 101).

The starting point is cycle time versus velocity for an on/off valve application (Figure 1). It is seen in Figure 1 that the velocity/time line is a rectangle. Because of the rapid shift time, the acceleration and deceleration are almost instantaneous. The distance traveled is equal to the velocity times the time. In more basic terms, it is the integral over time of the velocity trace that is the area of the rectangle in Figure 1.

To reduce the shock of the instantaneous shift time, the cycle can be altered as shown in Figure 2. The acceleration and deceleration are defined as 20% each of the total cycle time. These velocity "ramps" spread the energy transfer over a longer time to minimize any shock. However, it is obvious from Figure 2 that the area under the trapezoid curve is less than the area of the original rectangle. This means the actuator involved does not travel as far. Somehow, the distance represented by the area of the two triangles at each end must be added to the velocity curve.

If the application does NOT require that the distance be covered in the same time as when the on/off valve was employed, the additional distance can be added as shown in Figure 3. The cycle time is increased by one half of the total acceleration and deceleration time that, in this example, is one half of 40%, equaling a total of 120% of the original time. Figure 3 demonstrates that the extended trapezoid is equal to the original rectangle. The small triangle at the end of the cycle will fit perfectly in the "gap" triangle at the beginning of the cycle to produce a rectangle equal to Figure 1. Equal area means equal distance.

In most cases, this solution will not be acceptable. The user will not want to sacrifice cycle time for the benefit of lower shock and smooth operation. Given this requirement, the additional area to equal the rectangle must be obtained by going above the 100% velocity line as shown in Figure 4. This graph overlays a trapezoid on the original rectangle from Figure 1 with the top of the trapezoid at a level above the rectangle. The actuator must travel at a faster steady-state speed to make up for the extra time used for acceleration and deceleration. In graphic terms, the part of the trapezoid above the 100% line must equal the area of the two triangles below the 100% velocity line as shown in Fig. 4.

Before we get to the specifics, there is one more general consideration. The designer need only determine the balance between total acceleration/deceleration time and additional steady-state velocity. Though the ratio of acceleration to deceleration time may affect the final dynamic outcome, the ratio does not change the area under the curve. Only the total time matters. The following two figures demonstrate this point.

Figure 5 shows three different trapezoids all having the same level of steady-state velocity and the same total acceleration/deceleration time. The difference is the ratio of acceleration to deceleration time. One (yellow) shows only acceleration time, one (black) only deceleration and another (pink) equal acceleration and deceleration. The general formula for the area of a trapezoid is:

$$\text{Area Trapezoid} = [(a + b)/2] \times h$$

where

a = length of the top
b = length of the bottom
h = height (perpendicular distance from a to b).

All three of the trapezoids have the same area because they have identical a, b and h's. In fact, an infinite number of trapezoids of the same area can be constructed with these three dimensions all being identical.

Figure 6 shows the same concept for three triangles. If we use the entire cycle time for acceleration and deceleration,

Figure 1

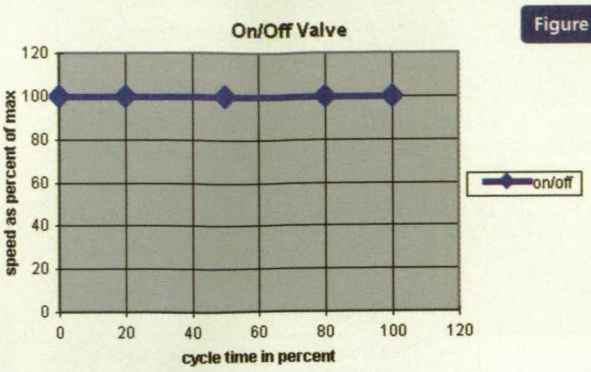


Figure 2

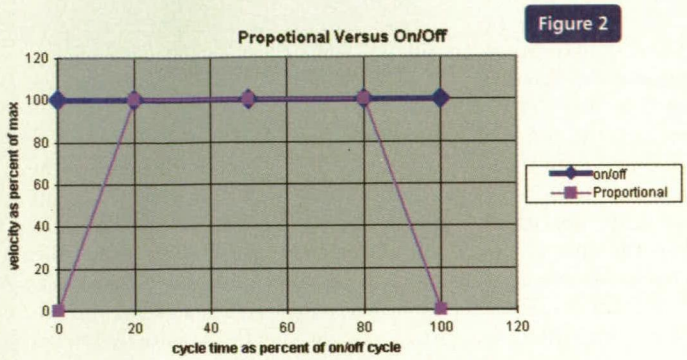


Figure 3

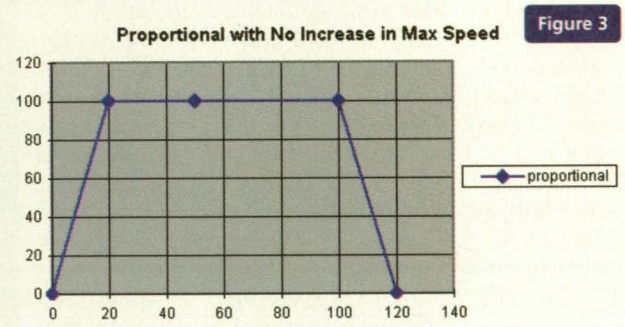


Figure 4

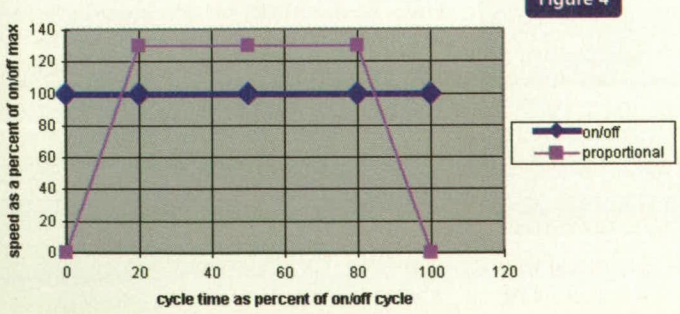
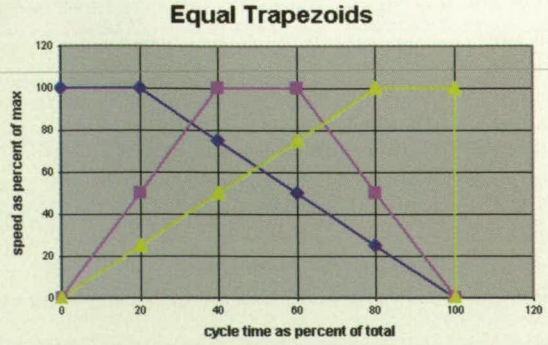


Figure 5



the velocity vs. time curve would be a triangle. The general formula for the area of a triangle is:

$$\text{Area Triangle} = 1/2(b \times h)$$

where

b = the base or bottom of the triangle
h = the height (perpendicular distance from the point to the base).

Based on this, the only decision remaining is determining the velocity increase required to exactly balance the acceleration/deceleration time required. In other words, the additional steady-state velocity will exactly gain the area under the velocity/time curve lost because of acceleration/deceleration time. Figure 7 is a complete graph that provides the designer with all the information required for that decision.

The horizontal axis is cycle time in percent of total cycle and the vertical axis is velocity as a percent of on/off velocity or the original velocity. Any point on the line corresponds to a pair of percent cycle time and percent increase in on/off velocity that will produce exactly the same distance traveled for the original on/off system. For example, if the designer considers using 40% of the cycle for acceleration and deceleration, then the steady-state velocity must be 125% of the original for a perfect match. For 60% the steady-state velocity would be just under 150%. If the choice were to use the entire cycle time for acceleration/deceleration, the velocity would have to be double. The basic trade-off is the more acceleration/deceleration time, which means more shock dissipation, the higher the steady-state velocity must be to perform the function in the same amount of time. Graphically, it is constructing a trapezoid of equal area to the original rectangle in Fig. 1.

For those who prefer a construction method to merely reading a graph, the author of this article will be glad to send the details. Please write to Paul Kuebler, Application Engineer, Parker Hannifin Corporation, Hydraulic Valve Division, 520 Ternes Ave., Elyria, OH 44035.

Figure 6

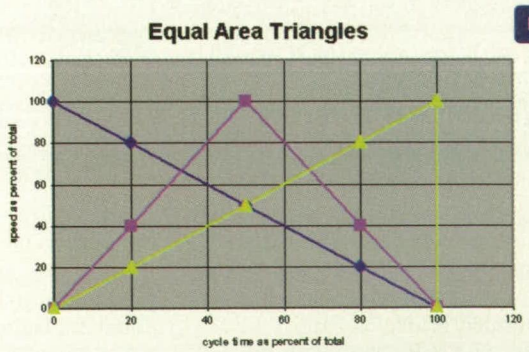
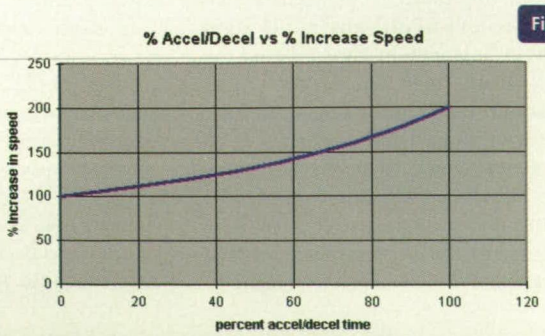


Figure 7



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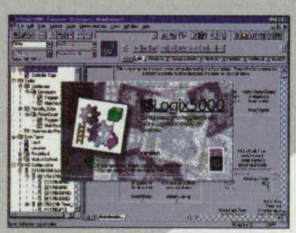

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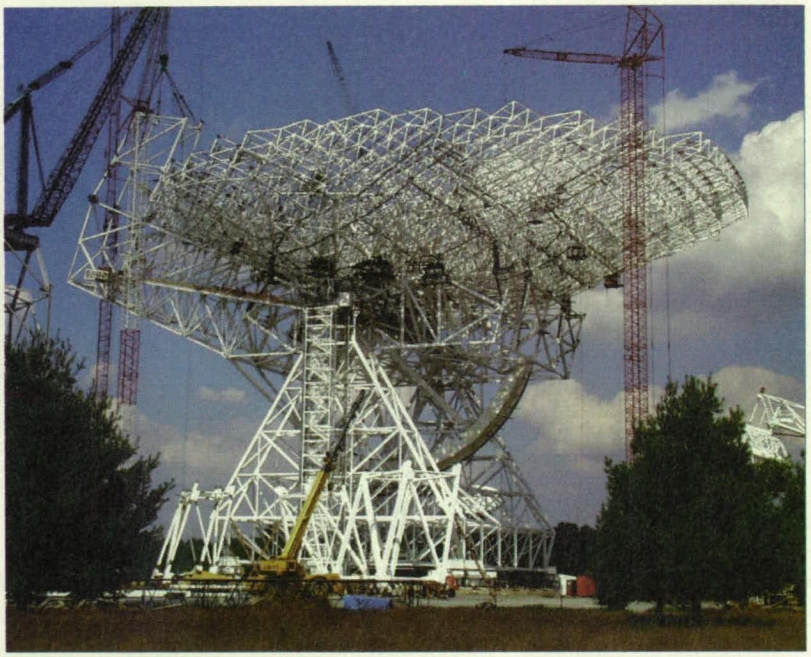


The Green Bank Telescope under construction.

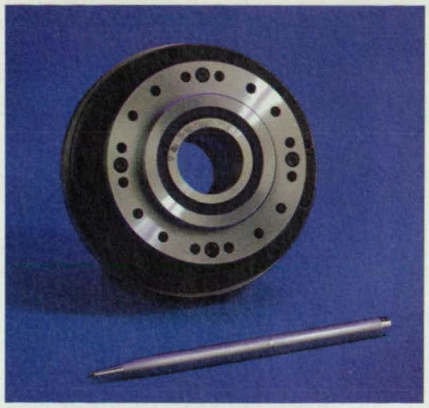
Custom actuators make the active primary surface of the NRAO's new radio telescope, to be the world's largest, fully adjustable for wind and temperature distortions.

Located on a verdant mountaintop in Green Bank, West Virginia, the National Radio Astronomy Observatory (NRAO) has been a major center of radio astronomy research in the U.S. since the late 1950s. Now, in a major expansion of its capabilities, the Observatory will soon be home to the world's largest fully steerable "active primary surface" radio telescope, featuring a 328-by-367-foot reflector. When finished, the telescope will have the capability to accurately adjust its huge reflector surface, which consumes 2.3 acres, thus compensating for any deviations in overall smoothness caused by gravity, wind, or temperature.

The new Green Bank Telescope (GBT), as it is called, is a $75-million structure m that will replace a 300-foot radio telescope that collapsed in 1988. The new GBT will utilize one set of drives to make the antenna's reflector pivot on a bearing, controlling its elevation, while another set of drives will rotate the entire antenna structure on a 210-foot-diameter circular steel track, controlling its azimuth.

The sheer size and scope of the GBT are mind-boggling. The reflector is 100 meters across, the radius of the elevation wheel that holds the reflector dish is 100 feet, and the weight of the total finished structure will be 15.7 million pounds. Andy Perkins, Director of Program Management of Comsat RSI, the telescope's construction contractor, said that the materials themselves are noteworthy.

"Physically," says Perkins, "this is the largest movable antenna in the world, which means we needed 53 tons of 105-foot-long beams, 16 wheels for overall structure rotation that are each 45,000 pounds—and were shipped one per semi trailer truck, five million pounds of steel for the base unit, called the alidade, and ten million tons of steel for the reflector and its support. If you can imagine a football field that is round, we've installed that 160 feet in the air, on



New, Hollow Shaft Gearing SHF Series

Featuring a through-bore up to 70 mm in diameter, the SHF Series component sets and gearheads enable the design engineer to pass shafting, wire bundles, or other components directly through the center of the gear. The new SHF Series provides high accuracy in a compact design. This unit design is both axially shorter and lower in weight, as compared to conventional harmonic drive gearing. This is accomplished by using HD Systems patented "S" tooth profile. Rated torques up to 6590 in-lb and positional accuracy better than 2 arc-min can be achieved. Gear reduction ratios of 50:1 through 160:1 are available in a single stage.

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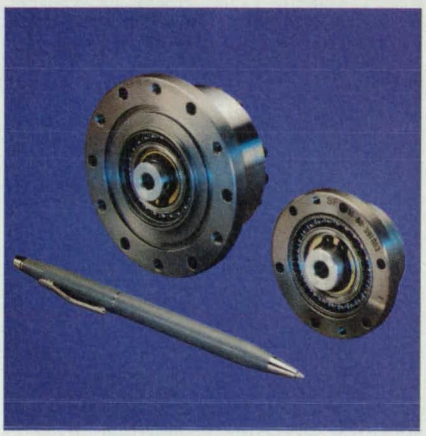

CSF Series

HD Systems offers higher performance harmonic drive component sets and gearheads using its patented "S" tooth profile. The CSF Series provides higher torque, higher torsional stiffness, and longer life, all in a smaller package while maintaining accuracy and efficiency. Reduction ratios of 50:1 through 160:1 are available with rated output torques ranging from 48 in-lbs to 31,400 in-lbs, depending on unit size.

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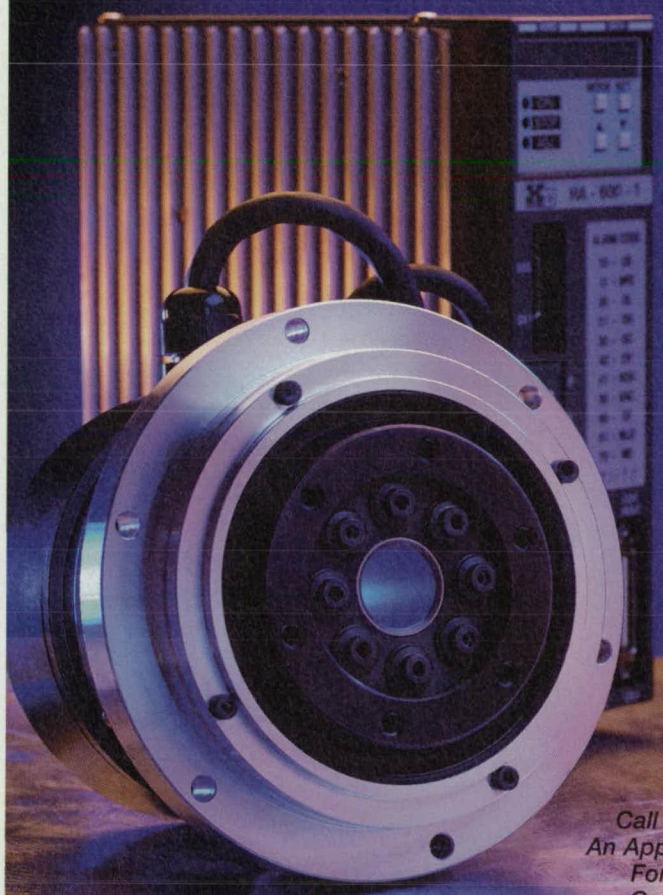

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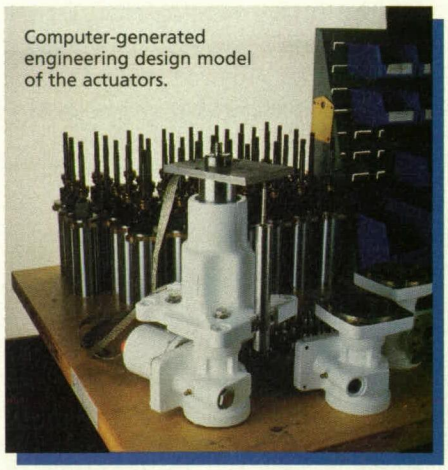
a structure that reaches 457 feet into the air. Just to start things off, I bought a semi trailer load of wire for welding and 500,000 feet of wire to connect the actuators that adjust the active surface. It's taken 20,000 man hours for field-welding of the alidade alone."

A Clear Aperture

An important design feature of the Green Bank Telescope is its open, unblocked aperture, with a single feed support arm and secondary reflector located at the top of the reflector, but rising from just one side. Previous antennas have usually had several metal struts in a pyramid shape in front of and at the center of the reflecting surface. The struts support the receiving equipment at the reflector's parabolic focus, but are a source of radio-wave interference and consequently affect radiation reception, frequently to the dismay of attending scientists and technicians. The GBT's clear aperture design collects radiation from the entire reflector, a circular area of 100 meters in diameter, allowing radiation to reach the reflector and then pass to the secondary reflector's focal point without meeting any obstructions that would block accurate reception. The secondary reflector captures the radiation and sends it to a "receiver room" that houses a variety of feeds and receivers, also located at the top of the single-feed arm.

The telescope is capable of rotating through a vertical arc from a minimum of +5 degrees (0 degrees being the horizon) to a maximum of +95 degrees (5 degrees beyond vertical). The entire antenna structure, reflector, and alidade are mounted on four sets of wheels, with four wheels per set. These immense wheels ride in a circular 210-foot-diameter track to allow complete 360-degree rotation. Providing what astronomers call "full sky coverage," the combination of horizontal and vertical rotations will allow the telescope to scan for radio waves anywhere in the sky.



Computer-generated engineering design model of the actuators.

The GBT's most unusual attribute, however, may be its "active primary surface," a unique departure from previous radio-telescope designs, in that the entire reflector surface is adjustable. A total of 2,204 aluminum panels, each 2 by 2.5 meters, make up the reflector surface, and each panel is supported in all four corners by electromechanical linear actuators custom-designed and manufactured by Industrial Devices Corporation of Novato, California. The surface of the installed panels deviates from the required parabolic surface by less than 75 μm rms. To maintain a completely accurate surface shape under all adverse environmental conditions, the actuators are computer controlled, correcting for deformations and distortions caused by gravity, wind, and thermal effects.

For a telescope the size of the GBT, the most significant surface distortions are caused by wind and temperature. But, as the telescope moves in elevation, many parts of the structure can distort as the

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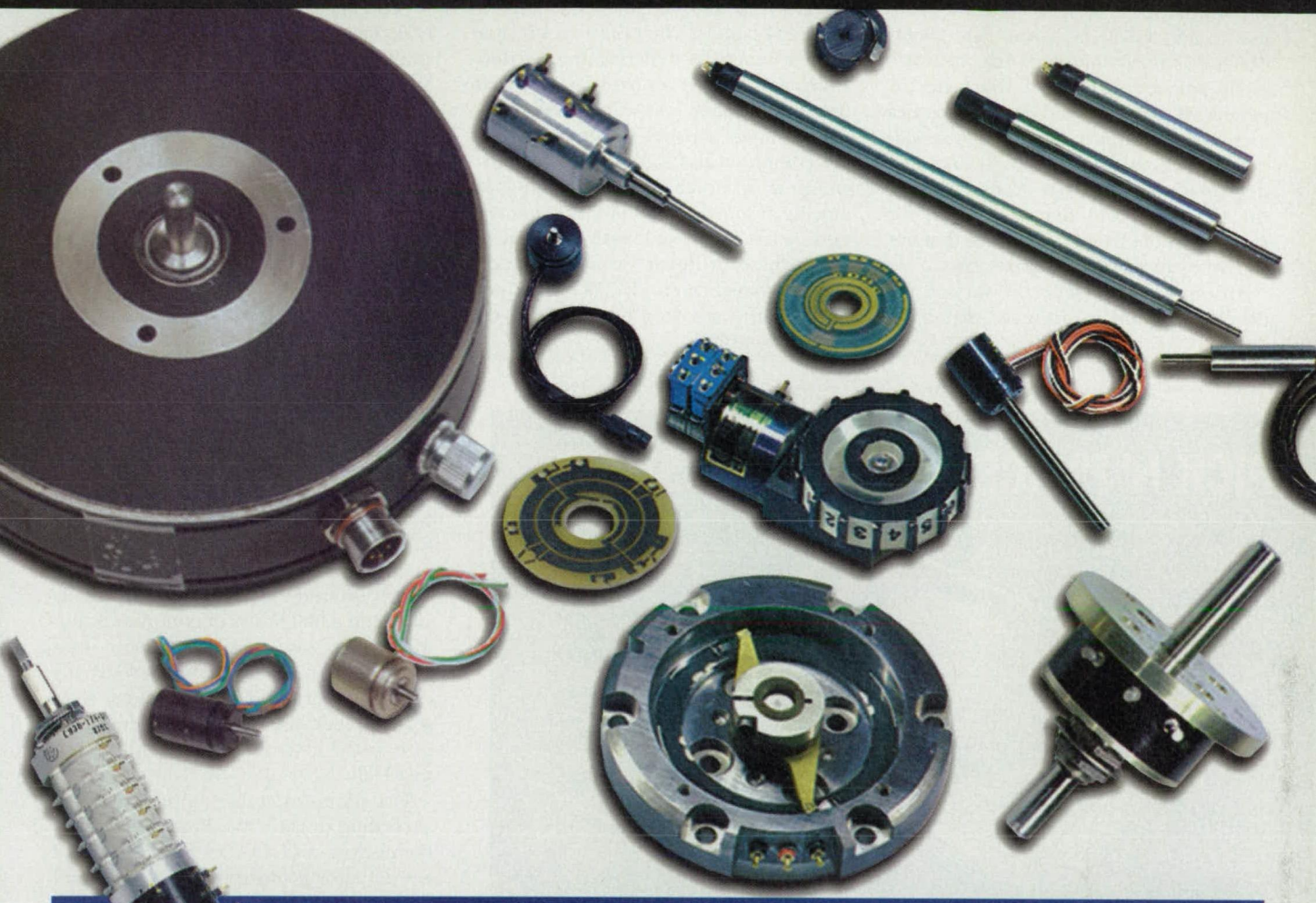

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direction of the force of gravity changes. To combat these surface accuracy problems, the GBT reflector has been designed to accommodate the measurement and adjustment of the reflector panels. As a result, the reflector becomes a continuous aluminum sheet that can be adjusted to correct the gravitational deformations that arise from elevating the telescope, and that can adjust for changes in the backup structure that are caused by temperature variations.

To measure the reflector surface for distortions from its accurate, parabolic norm, three rangefinders have been located on the feed support arm to individually measure the distance to each of the 2,204 panels. The range data is then fed to a computer to determine any deviations and how to return to an accurate parabolic surface. The adjustment calculation for each panel is determined by the computer and sent to the appropriate actuator, which adjusts the panels by moving at speeds up to 0.01 inch per second. Actuator stroke length is measured by means of a linear variable differentiation transformer (LVDT) mounted between the actuator housing and the panel assemblies.

Seeking a Twenty-Year Life Span

"The key to an accurate active primary surface was to select appropriate actuators," says Robert Hall, NRAO Project Manager of the GBT. "The final judge of how well an antenna performs is surface accuracy and frequency range. So it was very important that the actuators meet our specifications, which were primarily that they accurately move in extremely small increments of 0.01 in./sec., have a high MTBF, provide a lifetime of 20 years with 50,000 in. of movement each year, offer 200 pounds of side load capacity, be able to withstand winds up to 94 mph, and be completely resistant to Eastern mountain region weather conditions, including snowfall and a wide range of temperatures."

"Five companies sent in prototypes for evaluation and testing," says Hall, "and two companies' units didn't survive the initial testing." Of the three other companies, Industrial Devices' actuators clearly offered the longest MTBF, finally surviving 6,000 hours of continuous testing in one case, until the motor itself wore out, not the actuator. "Beyond any other concerns, IDC's actuators were selected because they could definitely give us the 20-year minimum life span," says Hall.

Five different motors were also tested, according to Hall, in addition to various connectors and LVDTs. The testing of the actuator prototypes, connectors and LVDTs began in late 1990 in a testing installation that was located in the middle of a field—the actual environment the components would experience during use. The testing was 1,000 hours of each prototype. In addition to IDC's actuators, motors from Sierracin Magnedyne, LVDTs from Lucas Schaevitz, and connectors from Tajimi were selected for the project.

NRAO has written the software for a computer program that controls actuator movement, but software for reading the LVDTs and motor controllers was supplied by Transition Technologies.

"This is a very significant radio telescope installation," says Hall, "and it is appropriate that the telescope it replaces at Green Bank was also important in its time." There is one earlier active primary surface telescope in the world, in Japan, but that installation is much smaller. "This project will have huge implications for radio astronomy in the next century, in ways that we can't even foresee at the present moment."

For more information, contact Rich Haus, Product Manager, at Industrial Devices Corp., 64 Digital Drive, Novato, CA; (800) 747-0064; fax: (415) 883-2094; E-mail: richh@idcmotion.com.


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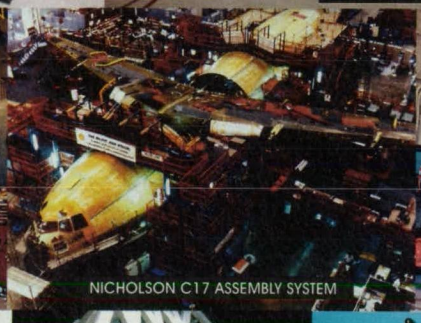
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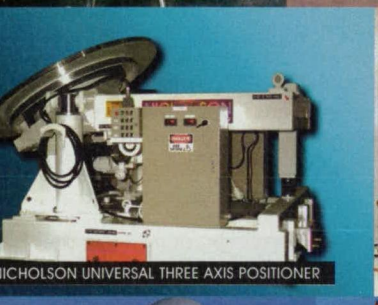
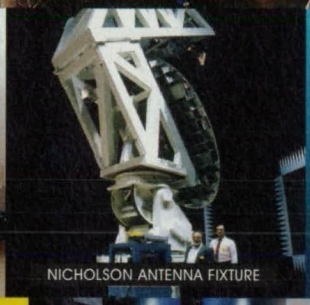

NICHOLSON UNIVERSAL THREE AXIS POSITIONER


NICHOLSON SATELLITE HANDLING FIXTURE


NICHOLSON ANTENNA FIXTURE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Hollow Shaft Actuators with Harmonic Drive Gearing

They can be used in demanding applications such as industrial robots and servo systems.

HD Systems, Hauppauge, New York

Harmonic drive gearing is recognized by designers for its zero backlash, high gear ratios, and compact design features. A recent development by HD Systems incorporates a large hollow shaft through the actuator, offering many benefits to the machine designer. The FHA hollow shaft actuator series allows cables, shafts, or tubing to be passed concentrically through the center of the actuator. Through this innovation, the series provides precision motion control and high torque capacity in very compact packages.

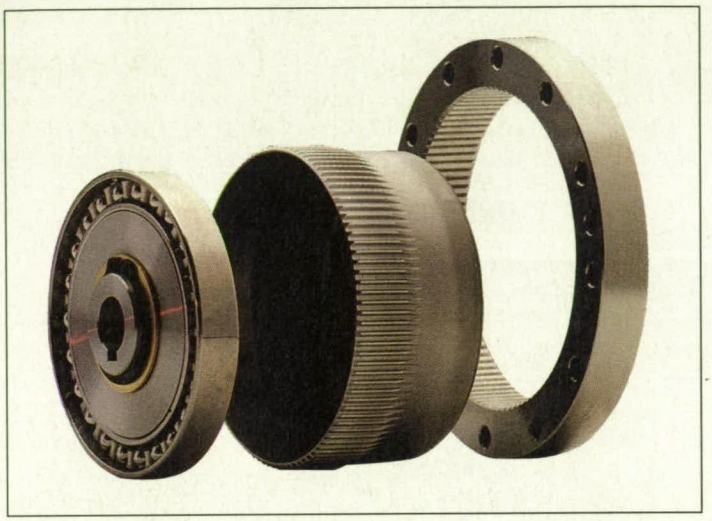


Figure 1. Harmonic drive gear **System Components.**

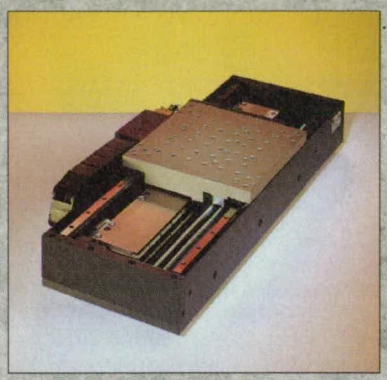
Another technical stride incorporated in this series is the patented "S" tooth profile, yielding higher torque capacity and torsional stiffness as well as twice the rated life of conventional harmonic drive gearing. Using this tooth profile, the CSF series delivers twice the performance of conventional harmonic drive gearing in roughly half the axial length. The SHF series offers the performance of the CSF with the additional benefit of a hollow shaft through the center of the gear.

Harmonic drive gears are made up of three basic parts (Figure 1). The circular spline (right) is a rigid ring with internal teeth, engaging the teeth of the flexspline (center) across the major axis of the wave generator. The flexspline is a nonrigid, thin cylindrical steel cup with external teeth on a slightly smaller pitch diameter than the circular spline. It fits over and is held in an elliptical shape by the wave generator, a thin raced ball bearing fitting onto an elliptical plug serving as a high-efficiency torque converter.

The three basic parts of the CSF series gears function in the following way (Figure 2). The flexspline is slightly smaller in diameter than the circular spline and usually has two fewer teeth. The wave generator's elliptical shape

AEROTECH

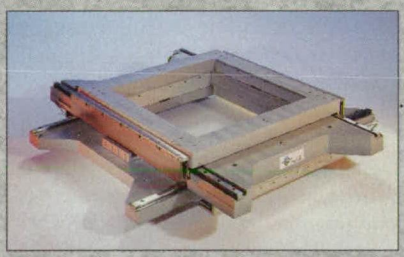
Motion Control Products and Positioning Systems



Positioning Stages

- Linear motor based designs provide superior velocity regulation, settling time and acceleration characteristics
- Air bearings: Aerotech is one of the leading manufacturers of precision linear and rotary air bearings
- Cost competitive standard and custom designs available for OEMs and end users
- Available with motor and position transducer– including laser interferometer– metric/English mountings, vacuum prep and more

Circle No. 625



Linear Motors and Drives

- Aerotech-manufactured brushless linear servo motors offer highest force per volume ratio, velocities to 350 ips and acceleration to 60 g!
- Modular, stackable "end-to-end" design allows for almost infinite combinations of travels
- Matched Aerotech brushless drives optimize performance, while providing lowest OEM cost
- Exceptional velocity control to 0.01%, fast settling times, and infinite resolution and accuracy capabilities

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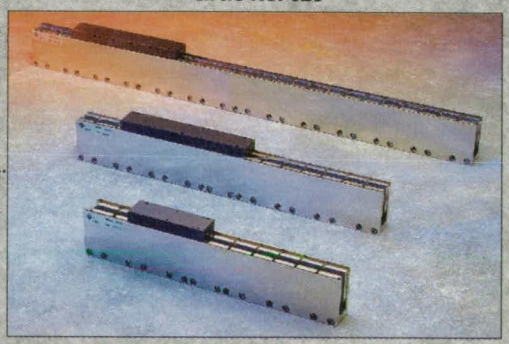

Motion Controllers

- Single and multi-axis controllers available with or without integral motor drives
- Open architecture, PC-bus motion controllers with up to 16 synchronized axes per card
- Motion capabilities from point-to-point moves through sophisticated multi-axis, cam table, cubic spline contouring, and G-code
- Sophisticated Man-Machine Interfaces built upon well documented Windows® 95 and NT 32-bit libraries with DLL, VBX and OCX development tools

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Brushless Rotary Motors & Drives

- Among the highest torque to inertia ratio
- Industry-standard NEMA frame size brushless rotary motors and matched drivers conservatively rated to 4000 rpm with continuous torques to 85 lb-in (9,6 Nm)
- Ultra-quiet linear and PWM brush and brushless motor servo drivers in easily integrated packaged or plug-in designs

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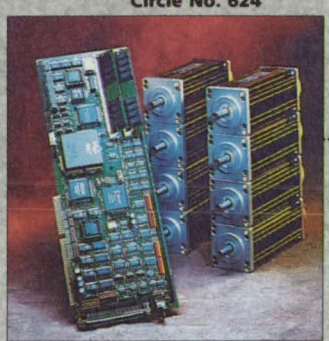

Custom Systems

Aerotech has over 25 years of design and integration experience with custom electro-mechanical systems, like this five axis air bearing system featuring nanometer level resolution.

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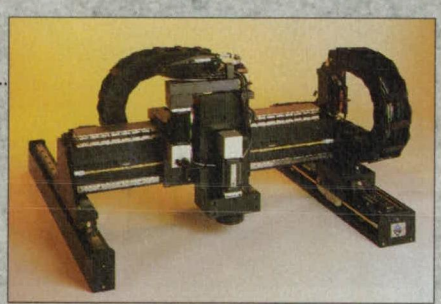

Linear Motor Gantry System

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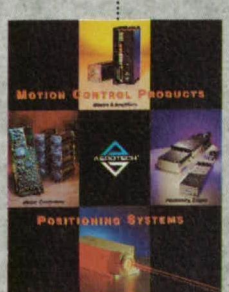

Motion Control Product Guide

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Circle No. 622

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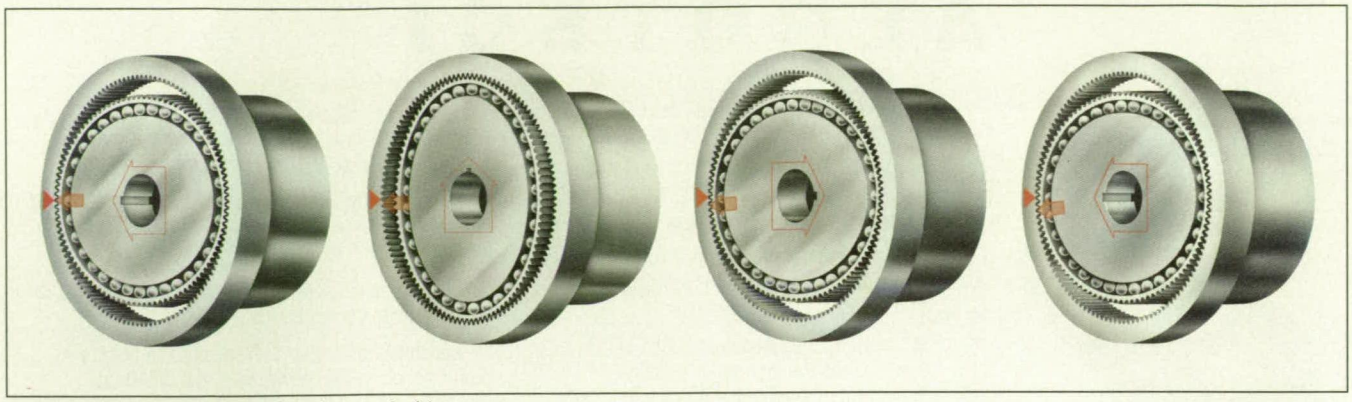

Figure 2. **Operating Principle** of the harmonic drive gear.

causes the teeth of the flexspline to engage the circular spline at two opposite regions across the major axis of the ellipse. As the wave generator rotates, the zone where the teeth of the flexspline engage those of the circular spline travels with the major elliptical axis. For each 180° clockwise movement of the wave generator, the flexspline moves counterclockwise by one tooth relative to the circular spline. Each complete clockwise rotation of the wave generator results in the flexspline moving counterclockwise by two teeth from its original position relative to the circular spline.

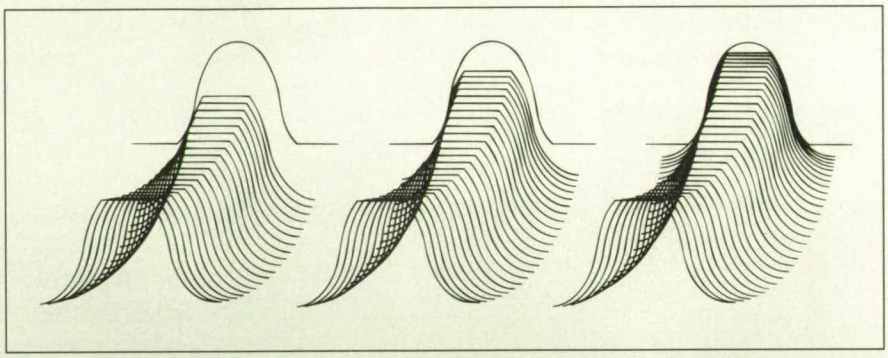

Figure 3. **"S" Tooth Gear Profile.** The improved features of this gearing make it suitable for servo applications where high rigidity and high peak torque capacity are required.

The reduction in the axial length of the CSF—depending on frame size, it can be almost 50 percent shorter than a conventional harmonic drive gear—is made possible by the "S" tooth profile. The wave generator imparts its elliptical shape onto the flexspline, which provides tooth engagement between it and the circular spline. The greater the ellipticity of the wave generator, the greater the radial deflection experienced by the flexspline. This deflection must not produce stresses above the fatigue limit of the material.

The "S" tooth harmonic drive gearing has a wave generator with far less ellipticity than conventional harmonic drive gearing. Thus the flexspline is subjected to less radial deflection. This allows its axial length to be shortened without increasing the stress level. As a result, HD Systems engineers have successfully delivered shortened axial length, high performance, and infinite life.

By combining increased performance with shortened axial length, the CSF achieves a fourfold increase in performance on a per-volume basis. For example, a robot's performance is determined by its payload, and the weight of the robot limits the payload capacity. The CSF decreases the robot's size, and thus its mass, and so it can increase its payload capacity.

The SHF series takes the additional step of incorporating a large throughbore capacity through the center of the gear. This is made possible by the development of the innovative "silkhat" flexspline. The conventional flexspline has a mounting boss on a smaller diameter than the toothbed. It has the shape of a cup, with the toothbed on the open end and the mounting boss on the bottom of the cup. The "silkhat" type has a mount-

ing boss on a much larger diameter than the toothbed. It resembles a top hat, with the mounting boss on the rim. Since the mounting boss's diameter usually limits the available through-bore, the silkhat design provides a much larger through-bore capacity. This allows machine elements such as tubes, shafts, or ballscrews to be passed through the center.

The input element can be driven by a hollow-shaft brushless motor. Another configuration involves using a pulley to drive the wave generator from a motor mounted on a parallel shaft, yielding the advantage that the motor can be mounted a short distance from the SHF gear for an optimum package size.

The "S" tooth profile, shown in Figure 3, significantly increases the region of tooth engagement. For the traditional tooth profile, about 15 percent of the total number of teeth are in contact, while for the new profile up to 30 percent are in contact. Figure 4 shows a region of tooth engagement. One end of this region is at the major axis of the wave generator ellipse where the teeth are totally engaged. The other end is where the teeth become totally disengaged. The increase in engagement results in a 100-percent increase in torsional stiffness in the low and medium torque ranges.

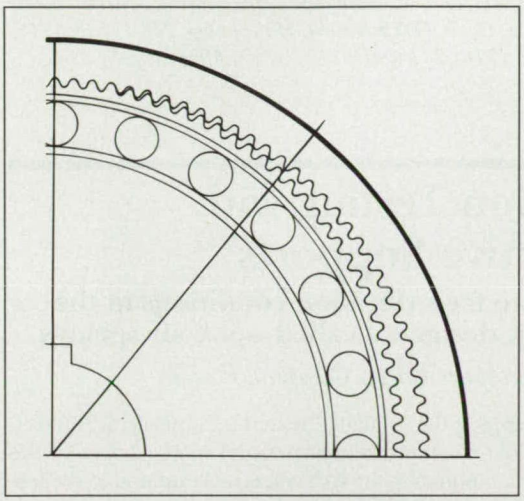

Figure 4. In the "S" tooth profile, **Up to 30 Percent** of the teeth are in contact.

The new tooth profile also features an enlarged tooth root radius, which results in a higher allowable stress and a corresponding increase in torque capacity. Furthermore, the enlarged region of tooth engage-

Motion Control Tech Briefs LITERATURE

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1998 MOTION CONTROL CATALOG

Galil's 1998 catalog is 128 pages with specs for ISA, PC/104, VME, and standalone motion controllers with RS-232. Features include: "Mix-and-match" steppers and servos on 1 through 8 axes, memory for application programs, uncommitted I/O, linear and circular interpolation, gearing and Ecam. Also, software for servo tuning and interface to AutoCAD, G-codes and Visual Basic. DOS, Win 3.1, 95 and NT. Catalog includes 28-page technical reference about motion control systems. Galil Motion Control, 203 Ravendale Drive, Mountain View, CA 94043; (650) 967-1700; 800-377-6329; fax (650) 967-1751; web site: www.galilmc.com

Galil Motion Control

For More Information Circle No. 620

ment leads to a more even loading of the wave generator bearing, resulting in more than double the bearing's life expectancy.

The FHA series actuators feature a through-bore up to 45 mm in diameter. These units consist of a DC brushless pancake motor, an encoder, and a precision harmonic drive gearhead. An encoder is built integral with the motor to reduce the axial length to a minimum. Rated torques up to 1730 in.-lb. and positional accuracy better than 1 arc-minute can be achieved. The FHA series is available in five frame sizes, ranging from 116 to 248 mm in length, and 128 to 300 mm in diameter.

For more information on harmonic drive gearing systems, please contact Brian St. Denis, **HD Systems**, *Hauppauge, NY 11788; (516) 231-6630; fax: (516) 231-6803; http://www.HDSystemsInc.com.*

Vibration Testing with Innovative Supports

To simulate free vibration conditions in the laboratory, designers called upon air springs.

Coleman Aerospace Corp., Orlando. Florida

When developing the guidance system of a missile, it is necessary to know the resonant frequencies and mode shapes of the missile in flight. Simulating the free vibration condition in the laboratory, however, is a difficult task, since the required supports can affect the test results.

To obtain more accurate data for use in developing the electronics and algorithms in the guidance system, Coleman Aerospace Corp. conducted ground vibration survey (GVS) tests on the missiles it designs and builds. For the GVS test, the

Figure 1. The overall missile is shown in its **Test Configuration**. Five cradles are located under the missile and the shaker used for exciting it is at the far right. The control panel for the air springs is next to the missile

missile is supported in a horizontal plane and excited at its aft end. To achieve accuracy, it is necessary to minimize the influence of the supports on the test results.

The missile under test was a short-range air-launched target (SRALT) Hera craft that weighed 21,300 lbs. (9700 kg) and measured 35 ft. (11 m) long. Previous tests used slings from an overhead structure to support the missile. Problems stemming from this setup included continual stretching of the slings and excitation of them under vibration. The stretching required frequent readjustments to maintain the proper load distribution and alignment with the shaker. The responses of the masses of the slings and chain falls, excited by vibration, influenced

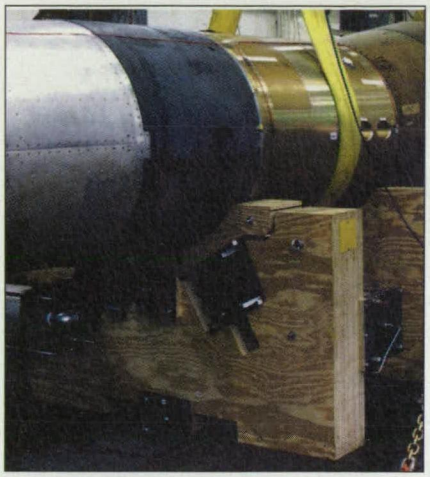


Figure 2. A **Cradle** is shown with the missile elevated on its saddle. The two air springs can be seen along with their air reservoirs.

the test results. To eliminate these problems, the missile was supported on air springs.

Two configurations of the missile were tested, with one representing the ignition (full motor) condition and other the burnout (empty motor) condition. The test setup for the missile is shown in Figure 1. For each configuration, three cradles supported the missile, with a pair of Firestone Airmount® springs in each cradle. Model 22 springs were used for the ignition condition and Model 20-2 springs were used for the burnout condition.

The axial stiffnesses of the air springs were reduced by placing a large air reservoir with each spring. The springs have minimal radial stiffness, so it was necessary to provide restraints to maintain the location of the missile when it was elevated on the inflated air spring. Lateral location was achieved by placing the air springs 30° from vertical. Longitudinal and roll location were achieved by the use of bungee chords attached to the missile near its center of gravity. The cradle configuration is shown in Figure 2, with the saddle supporting the missile raised to its test position one inch (25 mm) above the cradle.

The operation of the air spring system was simple and efficient. The missile could be raised from the resting position to the elevated—testing—position and be maintained there indefinitely. The only influence on the result was the added masses of the saddles supporting the missile, and these could be removed by post-test analytical calculations.

This work was done by the author of this article, Harry L. Schwab of **Coleman Aerospace Corp.**, *Orlando, FL. No further documentation is available from Coleman. For information concerning air springs, call Brian Hoaglan, Firestone applications engineer, at (317) 818-8745; E-mail hoaglanb@firestoneindustrial.com.*

Automated Propellant-Blending Machine

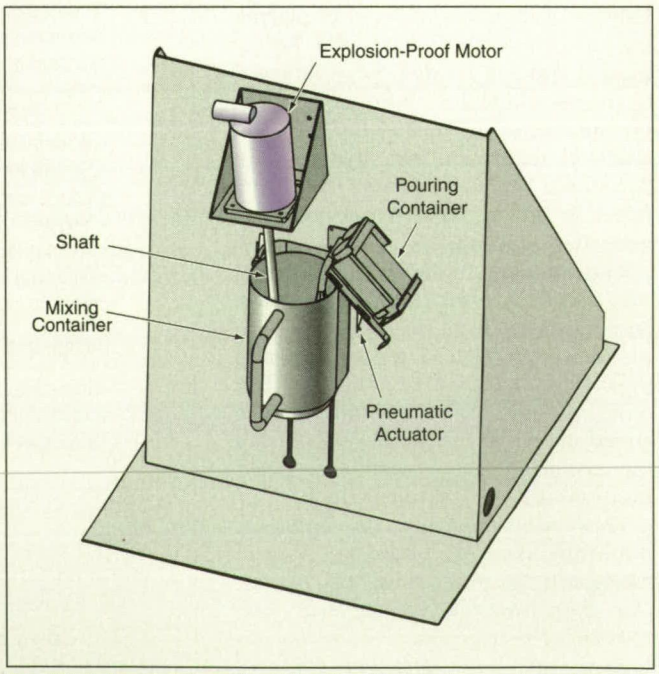
Production processes are faster and safer than before, and the product is improved.

Lyndon B. Johnson Space Center, Houston, Texas

The automated propellant-blending machine, a Johnson Space Center (JSC) innovation, refines the production processes of commercial rocket-propellant manufacturers by: (1) generating inert blends that contain particles of uniform size; (2) eliminating manual mixing, thereby speeding production and reducing the risk of injury or death; and (3) making it possible, with little or no modification, to produce a finer end-product for commercial and aerospace applications. These refinements are achieved by use of a nonproprietary technique — a significant departure in that commercial propellant manufacturers frequently use proprietary precipitation-drop techniques unavailable to other propellant manufacturers. One manufacturer has already expressed interest in the JSC automated propellant-blending machine.

Propellant-blending machines blend zirconium/potassium perchlorate (ZPP), titanium and titanium hydride propellants, and aluminum and magnesium compositions. Two commercial methods for blending ZPP are the evaporation method and precipitation blending. The disadvantages associated with the evaporation method are that the achievement of good blends depends upon, among other things, manual and frequent movement of mixtures, and production of the blends is dependent on the blender. Moreover, evaporation blending is dangerous; lives and limbs have been lost because of hazards associated with the blending process. The major disadvantage of precipitation blending is the unreliability of the process. The JSC automated propellant-blending machine overcomes the disadvantages of both evaporation and precipitation blending.

The JSC machine (see figure) includes a mixing container and a pouring container. An explosion-proof motor is connected by a shaft to an impeller (the blending actuator) in the mixing container.



The **JSC Automated Propellant-Blending Machine** is a product of continuing efforts at JSC to study and apply processes for blending ZPP into propellant mixtures.

In preparation for the blending process, a fluoroelastomer (Viton B or equivalent) is dissolved in acetone in proportions of 1:1, and the resulting solution is allowed to sit for a minimum of 24 hours. A required amount of hexane (which serves as a counter-solvent as explained below) is measured and put into a hexane fill container. The fluoroelastomer/acetone solution and the hexane are put into the mixing container. The active ingredients of the propellant mixture are placed in the pouring container. These ingredients include the following: (1) zirconium and graphite, which are placed on one side of the pouring container, and (2) potassium perchlorate, which is placed on the other side. At this juncture, personnel leave the machine, and the automated propellant-blending process begins.

During this process, the operation of the automated blending machine is controlled by a program executed on a personal computer. The program activates the explosion-proof motor, which rotates the shaft/impeller assembly. The program also activates a pneumatic actuator that tilts the pouring container to pour the active propellant materials into the acetone/hexane/fluoroelastomer solution in the mixing container.

A solenoid valve is opened to add hexane, and the amount of hexane added is measured. When the hexane-to-acetone ratio exceeds a certain value, the fluoroelastomer starts to precipitate from the solution and to coat the particles of the active propellant material. The desired amount of hexane to be added is the amount needed to precipitate the desired amount of the fluoroelastomer. Once the desired amount of hexane has been added, the solenoid valve is closed. After about 1 minute of mixing with the desired amount of hexane present, the computer tells the motor to stop. A ball valve opens, and the acetone/hexane solution is siphoned from the mixing container and deposited in an acetone/hexane disposal container. The ball valve is then closed.

The solenoid valve is opened and closed so that hexane can be added to the coated active ingredients. The computer orders the motor to rotate at a high speed for about 1 minute. The motor is then stopped and the ball valve is opened so that the hexane solution can be siphoned into the acetone/hexane disposal container. The mixing container is removed from the machine and the mixture is poured into a U.S. standard no. 30 sieve submerged in countersolvent. The sieved particles are dried in air at room temperature, then sent to an oven for final drying.

The automated process as described above is superior to the evaporation method or to precipitation blending in the following respects:

- The human factor is removed; this means that the blend is uniform and consistent, time is saved, the cost of producing the propellant mixture is reduced.
- The automated part of the propellant-blending process can be controlled remotely; this makes the process a lot safer by limiting the exposure of personnel.
- The speed of production is increased. As a consequence, the product can be delivered in a more timely fashion. Excluding drying time, one station can produce 400 g/hr.
- The mixing step is safer because the materials are not taken to dryness.
- The end-product is a loose powder that is much finer; this reduces the screening requirement.

This work was done by Paul Kemp, Carl Hohmann, and Maureen Dutton of **Johnson Space Center***; Bill Tipton, Jr., of Lockheed Martin; and Jim Bacak of G. B. Tech. No further documentation is available.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-22757.

New Products

Hollow Shaft Encoder

Stegmann Inc., Dayton, OH, says the new HG650 hollow-shaft incremental encoder has high resolution to 10,000 ppr and high reliability. With a 60-mm external diameter, the encoder offers an integral stator coupling with both axial and radial play compensation of ±0.5 mm, allowing liberal movement of the drive shaft, the company says. Weighing only 0.4 kg, the HG650 has a voltage range of 5-30 V, quadrature output signals with reference marker, and interchangeable collets for 6- to 12-mm shaft diameters. It has a maximum operating speed of 6000 rpm within a wide range of operating temperatures (-20 to 85 °C).

For More Information Circle No. 811

Miniature Air Cylinders

The Multi-Mount™ miniature air cylinders from Humphrey Products Co., Kalamazoo, MI, are lightweight cylinders that offer a range of interchangeable mounting brackets that attach to the cylinder ends for adaptability. Their rectangular design, the company says, makes installation simple and allows for precise mounting angles. Designed for precise pneumatic movement, the cylinders come in bore sizes of 1/4, 3/8, and 5/8 in. and are available in eight different single- and double-acting models, including nonrotating rod and double-end rod types. Maximum double-acting stroke is 1-1/4 in., and maximum single-acting stroke is 1/2 in.

For More Information Circle No. 814

Variable Frequency Drive

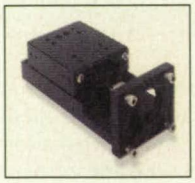
Mitsubishi Electric Automation Inc., Vernon Hills, IL, offers the A500 Series variable frequency drives. They have ratings of 0.5 through 100 horsepower at both 240 V and 480 V, and carry UL and CUL listings and CE marking. Their LCD display supports users in eight languages. The company says the A500's heat-sink fan controls and diagnostics maximize run time and reduce troubleshooting. The series offers an energy-saving mode that can provide significant money savings, Mitsubishi asserts, for lightly loaded motors in fan and pump applications, reducing motor noise and increasing life.

For More Information Circle No. 817

Permanent Magnet Stepper Motor

Thomson Airpax Mechatronics, Cheshire, CT, adds two models, the 26MO24B and the 26MO48B, to its line of 26-mm stepper motors. With a diameter of 26 mm and a length of 14 mm, the units produce between 0.75 and 0.90 oz.-in. in pull-out torque at 200 pps. Step angles are 15° (24 steps per revolution) and 7.5° (48 steps per revolution). Holding torque at 2.5 W is 1.3 oz.-in. for the 26MO24B and 1.5 oz.-in. for the 26MO48B. Bipolar and unipolar winding configurations are available. Permanently lubricated sintered bronze bearings are standard; radial ball bearings are available.

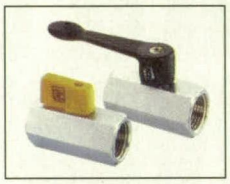
For More Information Circle No. 820



Miniature Linear Positioner

Industrial Devices Corp., Novato, CA, introduces the CP3 miniature linear positioner, with a 2.63 × 1.75-in. cross section, 1 to 5 in. of travel, load capacity to 50 lb. for horizontal motion, and vertical/axial load capacity to 15 lb. Bidirectional repeatability is 0.0005 in., drive accuracy ±0.0005 in./in., and linear speed to 4 in./sec. The CP3 has a lead-screw drive and nonrecirculating ball or roller bearings. Options include extended travel to 6 in., NEMA 17 motor adapter, and linear encoders with TTL or line driver output. IDC can modify the device for nonstandard environments including vacuum, clean room, and high/low temperatures.

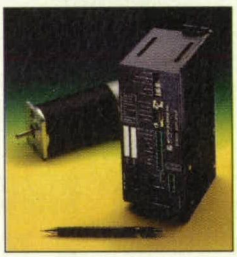
For More Information Circle No. 812



Brass Mini Ball Valves

Parker Hannifin Corp., Cleveland, OH, says that its MV200 Series brass mini ball valves are designed for use in confined areas where dimensional requirements limit the body size, and for any applications where it would be impractical or impossible to use a standard brass ball valve. The series has a working pressure of 200 psi and a temperature range from 0 to 250 °F. The extruded brass body is nickel-plated, with a quarter-turn handle for positive full shutoff. The valve has a blowout-proof stem, hard chrome plate ball and Teflon seats, and is available in 1/4, 3/8, and 1/2-in. female/female sizes.

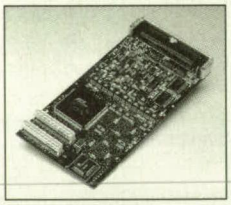
For More Information Circle No. 815



Brush-Type Servo Amplifiers

The Motion Science™ product line of Cleveland Motion Controls, Pittsburgh, PA, is expanded by the addition of the MDCX Series of brush-type servo amplifiers. Designed for use with brush motors from 500 W to 4 kW peak, the MOSFET pulse-width-modulated amplifiers provide four-quadrant control in torque and velocity modes. Available in a board-level or a housed version, the units are available in current ranges of 6 and 12 A. Power for an encoder is supplied by an on-board +5-VDC/250-A supply.

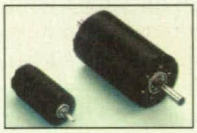
For More Information Circle No. 818



PMC Motion Control Module

Vigilant Technologies Inc., Davie, FL, announces the PMC-ENCDAC, a mezzanine card module that implements what it describes as a high-speed, high-density motion control interface board for the PCI bus. The module has 6 channels of quadrature decoder inputs, 6 channels of 12-bit DAC outputs, 30 channels of digital I/O, an interval timer, and a watchdog timer. All I/O is optically isolated from the host. The company says the analog output channels employ an on-board precision voltage reference and individual zero trims for maximum accuracy.

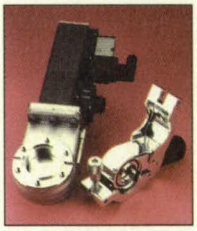
For More Information Circle No. 821



Neodymium Magnet Micromotors

The new series of micromotors from Micro Mo Electronics, Clearwater, FL, combine high-power neodymium magnet systems with high-current-carrying graphite brush systems, the company says. They come with up to 13 commutator segments and the System Faulhaber® skew-wound coil that contains no iron. Capable of operating at up to 155 °C, these motors, which measure 13 to 38 mm in diameter, can produce from 2 to 226 W of output power with mechanical time constants as low as 5.5 ms. All motors are available with encoders. A complete line of complementary in-line planetary gearheads with ratios up to 5,647:1 is available, boosting torque to 15 Nm.

For More Information Circle No. 813



Miniature UHV Gate Valves

VAT Incorporated, Woburn, MA, says its line of compact, miniature ultra-high vacuum gate valves feature conventional CF, ISO-KF flanges, or a new quick-change flange design with integral ISO centering rings and clamps for fast mounting. The Series 01 mini gate valves are available with aluminum or stainless-steel bodies in sizes from 5/8 in. to 2 in. ID. The company says the valves will provide 50,000 cycles before needing their first service. Rated for operation in the pressure range of 1×10^{-10} mbar to 2 bar, they are offered with manual and pneumatic actuators.

For More Information Circle No. 816

Mini-Linear Actuators

Ultra Motion, Mattituck, NY, describes its Smart Actuator series of mini-linear actuators as self-contained linear motion systems that offer high performance, reliability, and low-cost closed-loop servo control. The compact brushless linear actuators provide forces to 500 lb. and repeatability to ±0.0001 in. at speeds from 0.001 to 20 in./sec. They are available in standard stroke lengths of 2, 4, and 8 in. Options include precision acme or ball lead screws, zero-backlash nuts, a wide variety of end connections and trunnion mounts, and an anti-backdrive brake.

For More Information Circle No. 819

DeviceNet Brushless Servo Drives

API Motion Inc., Amherst, NY, makes available the Intelligent™ Series of brushless servo drives featuring DeviceNet, an industrial network. The drives are direct AC line-operated (115/208/230 VAC nominal), obviating the need for a power transformer. Four models are available with rated continuous output currents of 3, 6, 10, and 20 A, with continuous power ranging from 1.1 kW to 7.6 kW. Encoder- and resolver-equipped brushless motors are accommodated. The Intelligent Series drives have programmable I/O (6 in, 3 out), including fast-response inputs for registration-based moves.

For More Information Circle No. 822

Evaluation of Exhaust Flows From Thrust-Vectoring Nozzles

A unique dual-flow cold-jet facility supports flight research programs.

Dryden Flight Research Center, Edwards, California

A unique dual-flow, cold-jet facility has been developed and operated by California Polytechnic State University (Cal Poly) at San Luis Obispo for NASA Dryden Flight Research Center. The facility supports flight research on thrust-vectoring nozzles and thrust-vector control systems. To date, the facility has completed tests on subscale nozzles of the F/A-18 High Alpha Research Vehicle (HARV), the X-31 airplane, and the F-15 Advanced Control Technology for Integrated Vehicles (ACTIVE).

The facility contains a nozzle flow bench (see Figure 1) that incorporates unique features for research on single nozzles and on twin nozzles, which afford the ability to evaluate flow-interaction phenomena. Subscale nozzles are typically mounted on top of a thrust stand on the bench and connected to the end of an airflow-supply tube. The thrust stand is of a multiaxis design that affords capabilities for measuring all components of thrust and moment vectors.

A manifold system that supplies air to each nozzle independently is designed to avoid the introduction of extraneous side loads. The manifold system includes a plenum and bellows. Airflows at approximately equal rates are supplied on opposite sides of the plenum in order to cancel momentum and pressure effects that could otherwise be attributed to the air supply. This manifold design virtually eliminates extraneous forces from the air supply. In the dual-flow configuration, the flow rate or pressure ratio of each nozzle is independently controlled, providing maximum flexibility in testing.

The development of both the thrust stand and the air-supply manifold has made it possible to perform accurate research on thrust vectoring with small-scale nozzles. A capability for color schlieren photography has also been developed, making it possible to obtain visible records of complicated exhaust-flow fields and shock structures (for example, see Figure 2). A color schlieren video apparatus has also been built for use in evaluating the stability of exhaust -flow fields.

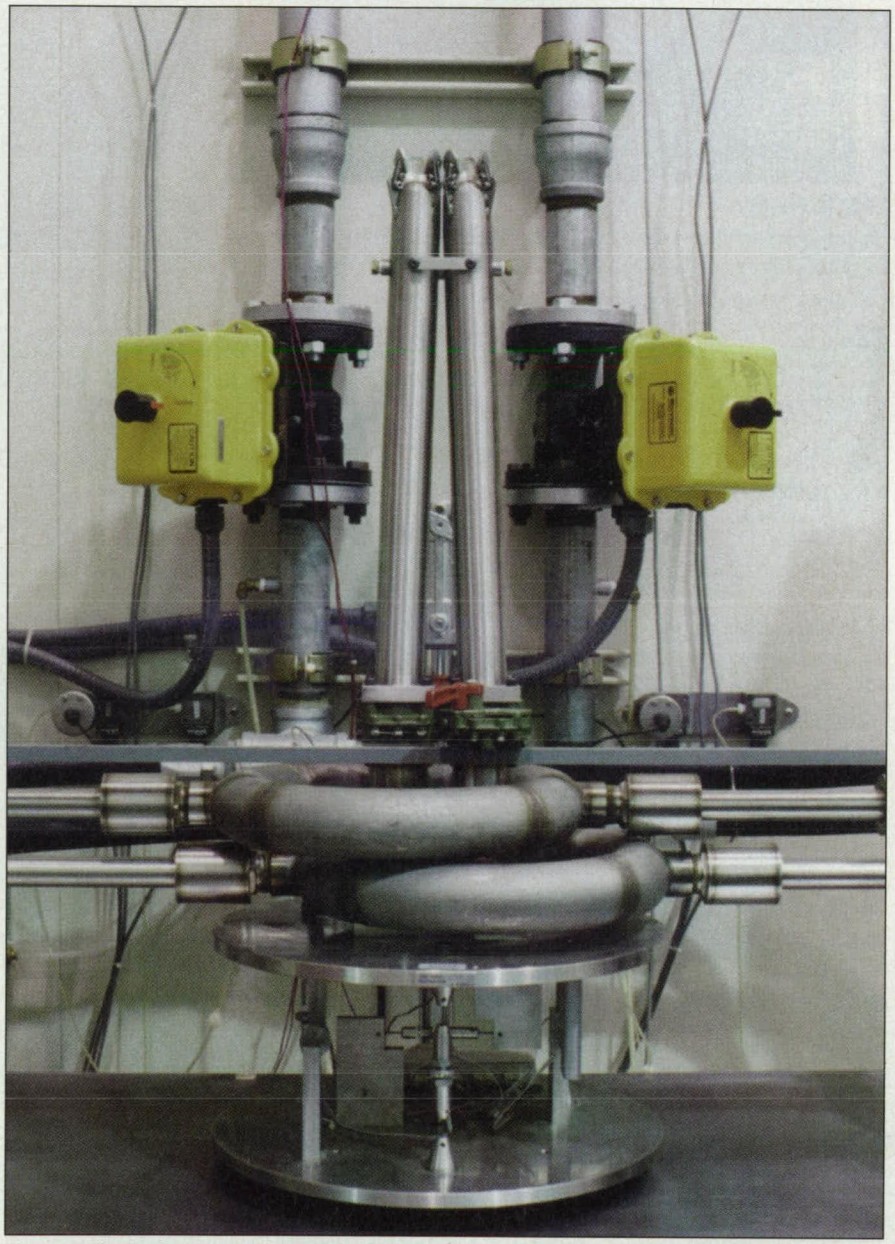
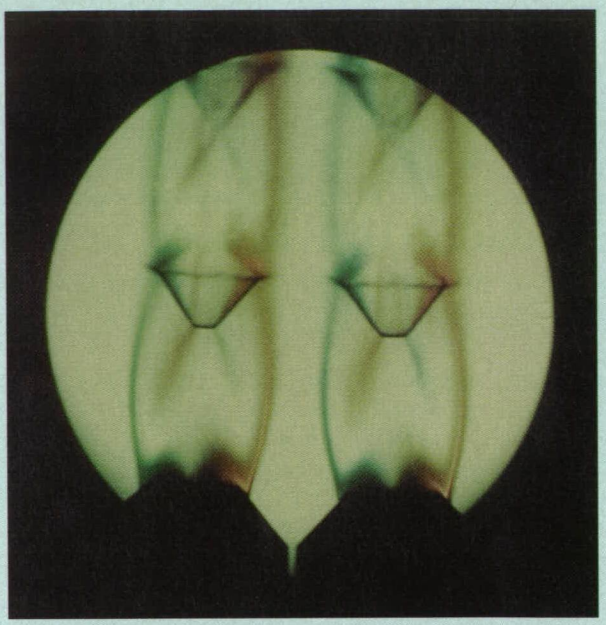


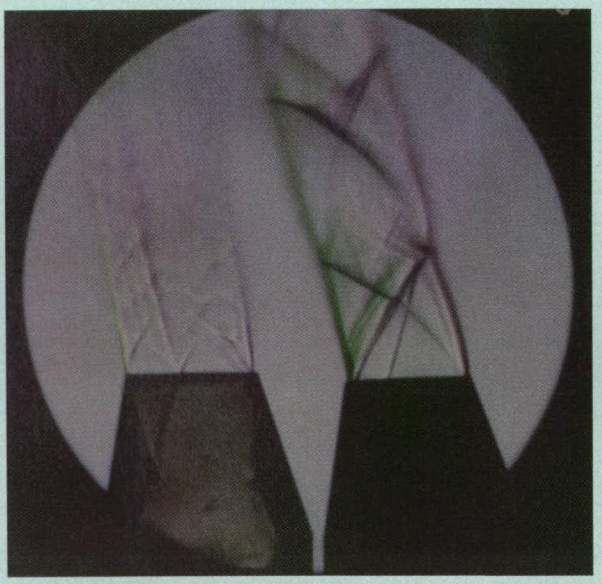
Figure 1. The **Equipment on the Nozzle Flow Bench** typically includes subscale nozzles mounted on top of a thrust stand and connected to a source of pressurized air via a manifold system that suppresses spurious air-supply-related side loads. The thrust stand enables measurement of all components of thrust and moment vectors.

To verify the accuracy of the cold jet, a single 1/24-scale F/A-18 HARV nozzle configured with postexit vanes was tested in this facility, and the results of the tests were compared with those of similar tests performed on a larger-scale model at Langley Research Center. These tests also enabled detailed evaluation of a postexit-vane-tip interference effect that was pronounced at higher pressure ratios.

Additional single-nozzle tests were performed on the X-31 nozzle configu-



Two Nozzles in F/A-18 HARV Configuration



Two-Dimensional Nozzle (TheTransparent One) and Three Dimensional Axisymmetric Nozzle Side by Side

Photos courtesy of Cal Poly.

Figure 2. These **Schlieren Photographs** reveal some aspects of the exhaust flows from scale-model pairs of thrust-vector nozzles in cold-jet tests.

ration to evaluate the effects of extreme deflections of post-exit vanes. Static-pressure ports were added to the divergent section of the nozzle to obtain data pertinent to concerns about operability. The results of these tests supported the implementation of a 10° increase in deflections of nozzle post-exit vanes on the X-31 airplane during its flight-test program, helping the aircraft achieve greater maneuverability.

One of the two-nozzle configurations shown Figure 2 was tested to explore the effects of flow interaction during thrust vectoring of the F/A-18 HARV. One of the main objectives of the tests was to validate a superposition assumption used in the design of the F/A-18 HARV thrust-vector control law. The assumption in question is that exhaust plumes from the two nozzles do not interact with each other and thus their

total-force vector can be determined by summing the force vectors of the individual nozzles as modeled in single-nozzle cold-jet tests. The aforementioned tests were the first documented tests to validate this superposition assumption. The results of the tests were found to support this superposition assumption, except at extreme vector angles, where one nozzle could impinge on a postexit vane of the other nozzle.

At present, the facility is testing thrust-vectoring nozzles with axisymmetric configurations, similar (except in scale) to full-scale, productionlike axisymmetric thrust-vectoring nozzles that are undergoing flight testing on the F-15 ACTIVE aircraft. The subscale-nozzle tests in the facility support the F-15 ACTIVE flight-test program. The results of in-flight measurements of nozzle vector plume angles have been found to differ significantly from those of corresponding measurements in subscale tests. The source of these differences has not yet been discovered, but finding this source is the primary goal of both the cold-jet (subscale) and the flight tests.

More specifically, 1/32-scale fixed-geometry vectored nozzles are undergoing tests in the facility. The primary immediate objectives of the cold-jet tests are to (1) attempt to reproduce the flight-measured vector plume angles and (2) evaluate and determine the locations and number of internal nozzle pressure sensors needed to measure in-flight pressure distributions accurately.

In addition, the tests accommodate some basic research on flow separation and stability. A unique test of a transparent two-dimensional nozzle has provided insight into the internal flow field of an axisymmetric thrust-vectoring nozzle. Part of Figure 2 presents images of the two-dimensional nozzle and a three-dimensional axisymmetric nozzle undergoing a test side by side at equal pressure ratios, vector angles, and throat and exit-area conditions. These tests have shown that the shocks inside the nozzles exert significant influence on the exhaust-flow field during thrust vectoring. Additional tests on axisymmetric nozzles instrumented with internal static-pressure probes are under way.

The data obtained in the facility have provided significant support to NASA's research on thrust-vectoring nozzles. Its relatively small scale and innovative approach have resulted in accurate, relatively inexpensive, and rapid testing, with such unique capabilities as its dual-flow capability. The schlieren photographic capability provides a valuable insight into flow-field properties, and the schlieren photographs augment the force and moment data traditionally available from cold-jet facilities.

This work was done by Albion H. Bowers, John S. Orme, and Ronald J. Ray of **Dryden Flight Research Center** *and Thomas Carpenter and Jim Gerhardt of California Polytechnic State University. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Thomas Carpenter
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San Luis Obispo
Department of Mechanical Engineering
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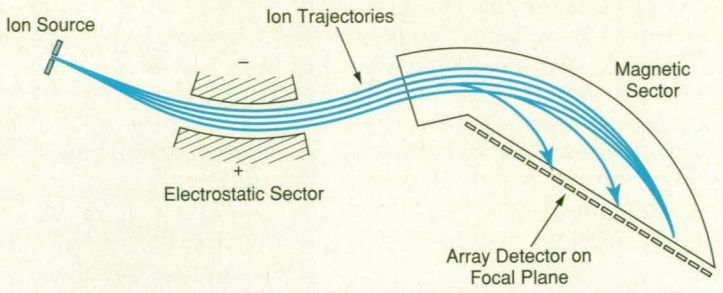
Monolithic Electrostatic Sector for Miniature Mass Spectrometers

The cost of fabrication is reduced considerably.

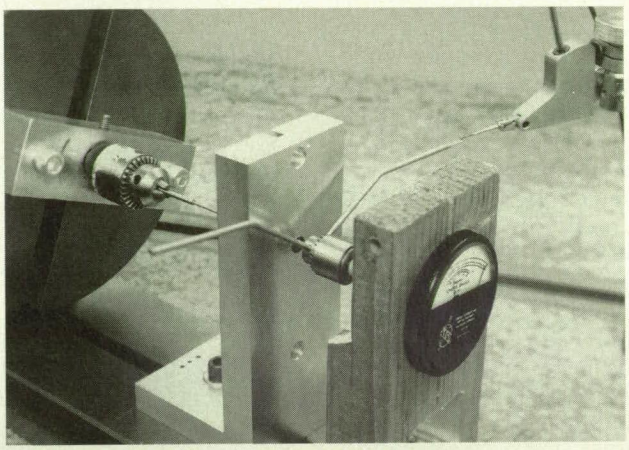
NASA's Jet Propulsion Laboratory, Pasadena, California

An improved miniature electrostatic sector has been designed for a miniature double-focusing mass spectrometer (see figure). Miniature mass spectrometers are essential components of high-performance, miniature, low-power instruments that are being developed for use in analyzing chemical compositions of small amounts of substances (e.g., toxic chemicals in the environment) in scientific laboratories, in industrial settings, and in the field.

Precision is critical in the design and fabrication of an electrostatic sector for a mass spectrometer. Especially notable is a very tight tolerance on the radii of the sector rails (the concentric



SIMPLIFIED PLAN VIEW



PHOTOGRAPH OF PROTOTYPE

A **Mass Spectrometer of Mattauch-Herzog Geometry** includes an electrostatic sector plus a magnetic sector that ends in an array detector on a focal plane. The electrostatic sector is made from a single piece of machinable ceramic and has a mass of only 30 g.

cylindrical electrode surfaces); for this particular electrostatic sector, the nominal inner and outer radii are 29.21 and 30.48 mm, respectively, and the difference between these radii must not vary by more than 10 μm over the entire arc. In an older design, the two rails were fabricated separately, making it necessary to resort to an elaborate and laborious procedure to align them with each other to satisfy the radius requirement as well as to obtain the required precise alignment between these rails and the other spectrometer components. The older two-piece design also made it difficult to maintain alignment during transport. These difficulties of establishing and maintaining alignment added significantly to the cost of fabrication and limited use to applications in which ruggedness was not needed.

The improved electrostatic sector is inherently rugged and dimensionally stable because it is made from a single piece of a machinable ceramic. The electrodes are made by plating the machined concentric electrode surfaces with nickel to a thickness of 6 μm. Reference surfaces for alignment are machined onto the single piece of ceramic; these surfaces are designed to be positioned on alignment ridges on a mounting plate that is also a precise component of the mass spectrometer. Two screws hold the unitary electrostatic sector in place with the reference surfaces pressing against the alignment ridges. Thus, provided that the concentric electrode surfaces and the reference surfaces are machined within tolerances, alignment of the electrodes with the other components of the mass spectrometer is assured. As a result, the cost of fabrication is no more than about 1/40 of that of the older electrostatic-sector design.

This work was done by Mahadeva P. Sinha of Caltech for **NASA's Jet Propulsion Laboratory.** *For further information, access the Technical Support Package (TSP) free on-line at* ***www.nasatech.com*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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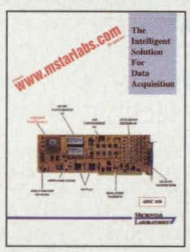

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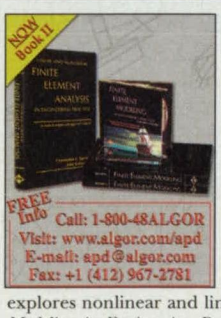

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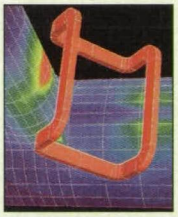

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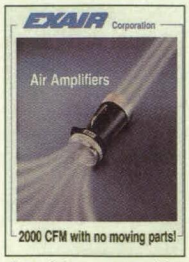

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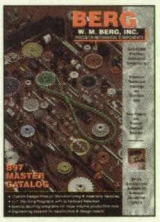

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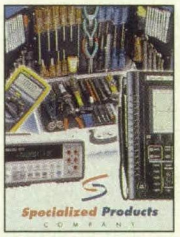

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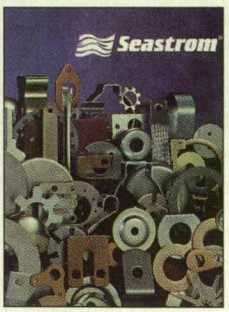

THE SOURCE FOR ELECTRONIC & MECHANICAL HARDWARE

Seastrom takes pride in offering one of the widest selections of standard electronic and assembly hardware available from stock. Seastrom's 66-A Catalog provides a complete source for over 45,000 products. For a free 550-page catalog, call 800-634-2356.

Seastrom Manufacturing Co. Inc.

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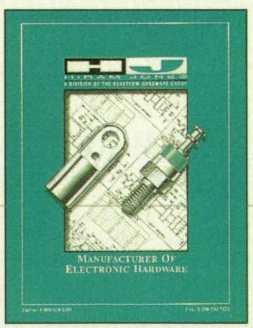

Hiram Jones Electronics, Inc./A Division of the Seastrom Hardware Group manufactures a complete line of standard miniature and sub-miniature terminals including: insulated test jacks, assembled standoffs and press-type terminals. All standard catalog items are available for immediate pricing and delivery. Call today for your free 27-page catalog: 800-634-2356.

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For More Information Circle No. 653

FREE 1998 PRECISION OPTICS CATALOG

Edmund Scientific's New 1998 Catalog features hundreds of technical solutions from our inventory of precision optics, machine vision, and optical components. All off-the-shelf precision optics and optical instruments are available in prototype and production quantities and pricing. Engineering assistance and custom products available for production orders. Edmund Scientific Co., Industrial Optics Division, Dept. B981 N954, Barrington, NJ 08007; Tel: 609-573-6250; Fax: 609-573-6295; e-mail: industrialoptics@edsci.com; www.edsci.com

Edmund Scientific Co., Industrial Optics Div.

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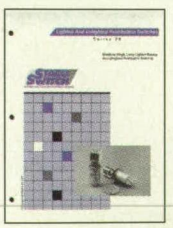


SERIES 70 MINIATURE LIGHTED & UNLIGHTED SWITCHES

StacoSwitch offers Series 70 — a wide range of miniature switches that are resistant to wet, dusty, or oily conditions. The switches meet control and instrumentation requirements and come in a variety of display types, colors, and lighting styles. Options include: DPDT MOM or ALT; T-1 LED or incandescent MFB lamps; and drip/splash-proof seal. StacoSwitch; Tel: (714) 549-3014; Fax: (714) 549-0930; e-mail: mrktg@stacoswitch.com; www.stacoswitch.com

StacoSwitch

For More Information Circle No. 655

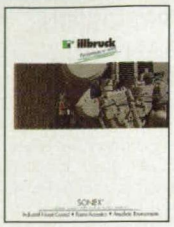
LITERATURE SPOTLIGHT

VIBRATION ISOLATION & IMPACT ABSORPTION

New, full-color brochure describes the dynamic properties of Sorbothane, the unique vibration isolation and impact absorption material. New test data details the damping properties of Sorbothane compared to other elastomers. Sorbothane is a patented visco-elastic polymer. Includes information on Sorbothane's new line of advanced vibration isolation/shock absorption products, as well as applications engineering, manufacturing capabilities, and the many applications for Sorbothane. Sorbothane, Inc.; Tel: 330-678-9444; Fax: 330-678-1303; e-mail: webmaster@www.sorbothane.com; http://www.sorbothane.com

Sorbothane, Inc.

For More Information Circle No. 656



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Reduce the pain and cost of industrial noise with SONEX acoustical products. SONEX acoustical products contain loud noise at its source or absorb overall noise in your facility. SONEX™curtains, SONEX™prospec, and SONEX™modular can be used as barrier walls or enclosures to surround noisy equipment or processes. SONEX panels, wedges, and baffles absorb overall noise and echoes. Call illbruck, inc. at 800-662-0032 for a free brochure on Noise Control, or visit our web site at www.illbruck-sonex.com

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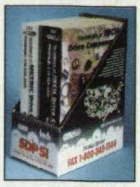

NEW INCH & METRIC DRIVE COMPONENT CATALOG SET

Free 1,152-page "Handbook of INCH Drive Components - 787" and 896-page "Handbook of METRIC Drive Components - 777" feature over 62,000 off-the-shelf standardized commercial and precision quality components, including over 4,200 new products. Products include gears, belt and chain drives, shafts and shaft accessories, bearings, couplings, universal joints, vibration mounts, gearheads and speed reducers, right-angle drives, brakes and clutches, motors and gearmotors. Stock Drive Products/Sterling Instrument; Tel: 516-328-3300; Fax: 800-737-7436; www.sdp-si.com

Stock Drive Products/ Sterling Instrument

For More Information Circle No. 658

NEW CATALOG FROM LOVE CONTROLS

Love Controls' new full-color, 108-page 1999 Catalog shows the company's latest products. Features include the world's first and only dual-display 1/32 DIN temperature/process control, thermocouples, and RTDs; power controls, indicators, recorders, and data-acquisition products. Love Controls Division, Dwyer Instruments, Inc., PO Box 338, Michigan City, IN 46361-0338; Tel: 219-879-8000; Fax: 219-872-9057; love@love-controls.com; www.love-controls.com

Love Controls Division, Dwyer Instruments, Inc.

For More Information Circle No. 659

PIEZO-EFFECT ELECTRONIC SWITCHES

Technical brochure features vandal-proof, single-key piezo switches: long-life, plastic or metal housings; LED point or ring illumination; and contact-free switching. "EX" type meets ignition protection requirements of EN 50020 (ib IIC T4) for intrinsic safety, with TUV approval, for use in potentially explosive environments containing combustible gases, vapors, dust, or fibers. SCHURTER; Tel: 800-848-2600; Fax: 707-778-6401; e-mail: info@schurterinc.com; www.schurterinc.com

SCHURTER INC.

For More Information Circle No. 660

ELECTROMAGNETIC VIDEO & PULSE DELAY LINES

For the past three decades, ALLEN AVIONICS has produced delay lines for many applications. The company manufactures all types of analog and digital delay lines, including fixed, tapped, and variable. ALLEN AVIONICS' new 48-page catalog features a complete product family of delay lines for industries such as broadcast, medical, communications, test equipment, and radio paging. ALLEN AVIONICS, INC.; Tel: 516-581-6803; Fax: 516-277-3129

ALLEN AVIONICS, INC.

For More Information Circle No. 661

FRICTION DATA GUIDE ON METALS AND COATINGS

General Magnaplate's updated Friction Data Guide slide chart shows Static and Dynamic Coefficients of Friction obtained from mating tests conducted on 69 combinations of materials. These include many Magnaplate-applied super-hard, dry-lubricated surface enhancement coatings. The easy-to-use format aids in selecting combinations that can improve the service life of mating components. General Magnaplate, 1331 Route 1, Linden, NJ 07036; Tel: 800-852-3301; Fax: 908-862-6110; e-mail: info@magnaplate.com; www.magnaplate.com

General Magnaplate Corp.

For More Information Circle No. 662

SHIELDING SYSTEMS FOR INDUSTRIAL APPLICATIONS

Lindgren RF Enclosures, Inc., the world's leading manufacturer of EMI shielded enclosures, is offering an 8-page brochure on its Double Electrically Isolated (DEI) RF Enclosures. DEI enclosures provide the highest level of EMI/RFI shielding available for a variety of industrial, communications, and government applications. They also meet high-performance requirements for pager, cordless and wireless repair, cellular system production, security, research, and EMI/RFI testing and calibration. Lindgren RF Enclosures, Inc., 400 High Grove Blvd., Glendale Heights, IL 60139; Tel: 630-307-7200; Fax: 630-307-7571

Lindgren RF Enclosures, Inc.

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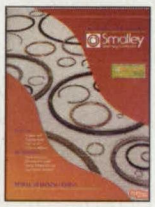

SPIRAL RETAINING RING CATALOG NO. RR-98

Our newly released 56-page Catalog No. RR-98 offers more than 2000 standard retaining rings, stocked in diameters from 1/2" to 16" (12mm to 280mm), in both English and metric sizes and in carbon and stainless steel. Also included are a Ring Selection Guide; comprehensive Engineering Design Formulas; and data for materials, shear, bending, RPM, installation stress and groove design. Special rings are easy, too! Our no-tooling-cost Edgewinding process enables two-week deliveries for most sizes. Smalley Steel Ring Co., 385 Gilman Ave., Wheeling, IL 60090; Tel: 847-537-7600; Fax: 847-537-7698; www.smalley.com

Smalley Steel Ring Co.

For More Information Circle No. 664

OMEGA ENGINEERING, INC. SOFTWARE ON CD

OMEGA has just released its latest Data Acquisition CD. The CD contains the complete 600-page handbook in electronic format. It also includes product and demonstration software, a corporate video, and an electronic copy of OMEGA's latest technical publication: Transactions in Measurement and Control: Volume 2 - Data Acquisition. To request a free CD, contact OMEGA Engineering, Inc. at www.daiseee.com or call 1-800-327-4333. To obtain a CD request form by fax, call 1-800-848-4271 from any Touch Tone phone and request Document #9990.

OMEGA Engineering, Inc.

For More Information Circle No. 665

STATIC ELIMINATORS

EXAIR-Ionizers remove static and dust in many applications and contain no radioactive element. Air-delivered ions neutralize static and clean surfaces up to 20 feet away. Three styles include ionizing air knife, air cannon, and hand-held air gun. Applications include web cleaning, pre-paint auto-body blowoff, and neutralizing plastic parts. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH, 45246. Tel: 800-903-9247; Fax: 513-671-3363; e-mail techelp@exair.com; www.exair.com

EXAIR Corporation

For More Information Circle No. 666

ELECTRONIC HARDWARE

Globe Electronic Hardware, Inc. introduces its latest 260-page catalog, which provides complete engineering dimensions and specifications for our entire line of precision electronic hardware. Products include: Standoffs, Spacers, Captive Panel Screws, Retainers, Handles, Ferrules, and other quality components in both American and METRIC standards. Globe Electronic Hardware, Inc.; Tel: 800-221-1505; Fax: 718-457-7493; www.globelectronics.com

Globe Electronic Hardware, Inc.

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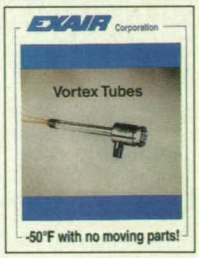

VORTEX TUBES

EXAIR Vortex Tubes produce up to 10,000 Btu/hr. with no moving parts. Tubes convert an ordinary supply of compressed air into two streams: one hot and one cold. Temperatures are adjustable from -50° to +250°F. Applications include: cooling hot melts, cutting tools, welding horns, electronic controls, soldered parts, and gas samples. EXAIR Corporation, 1250 Century Circle North, Cincinnati, OH 45246-3309; Tel: 800-903-9247; Fax: 513-671-3363; e-mail: techelp@exair.com; http://www.exair.com

EXAIR Corporation

For More Information Circle No. 668

NEW PRECISION MECHANICAL COMPONENTS CATALOG

PIC Design has published Catalog 44, their biggest ever. The catalog includes an expanded line of linear motion systems, modular framing elements, and belts and pulleys. Also featured are PIC Design positioning tables, ball slides, lead screws, precision gears, bearings, shafting, couplings, and hardware. Many components are available in both inch and metric sizes. PIC Design, Box 1004, Middlebury, CT 06762-1004; Tel: 800-243-6125; Fax: 203-758-8271; e-mail: info@pic-design.com

PIC Design

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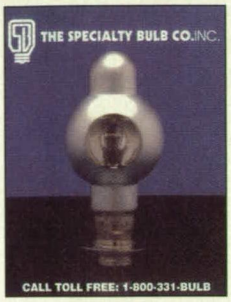

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The Specialty Bulb Co. Inc.

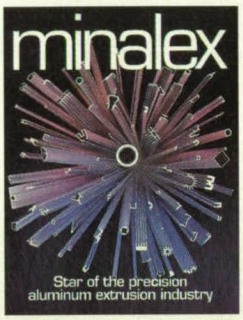
For More Information Circle No. 670

INSTRUMENT DATA ACQUISITION

The SoftwareWedge™ directs serial (RS-232, RS-485, RS-422) data from any instrument into any Windows 3.x, 95, or NT application such as Excel, MMIs, VB, Control, and Statistical applications. This configurable driver provides full data acquisition and control of PLCs, data loggers, scales, flow meters, lab instruments, etc. Please contact TAL Technologies, Inc., 2027 Wallace St., Philadelphia, PA 19130; Tel: 800-722-6004 or 215-763-7900; Fax: 215-763-9711; http://www.taltech.com

TAL Technologies, Inc.

For More Information Circle No. 671



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New! An informative brochure from MINALEX, leader in close tolerance shapes to 3 1/2", illustrates typical applications and describes capabilities including short runs. MINALEX, quality leader, delivers on time, every time. MINALEX, PO Box 247, Whitehouse Station, NJ 08889; Tel: 908-534-4044; Fax: 908-534-6788.

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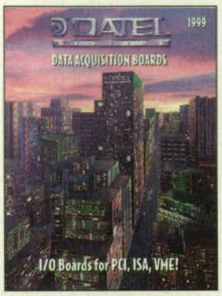

FREE DATA ACQUISITION CATALOG

Datel Systems' new 1999, 224-page catalog offers a wide range of high-speed, high-performance, and multi-function data acquisition boards. Over 100 new products are offered, including advanced-performance boards for PCI, ISA, and VME bus. Tel: 800-233-2765; Fax: 508-339-6356; e-mail: sales@datel.com; www.datel.com

Datel Systems

For More Information Circle No. 673

FREE TEST SOLUTION CATALOG

New, free, 64-page 1998 PC-Based Test Solution Source Book from Geotest (Marvin Test Systems, Inc.). Features over 100 PC-based products for ATE, data acquisition, and test & measurement applications. New products featured include: GT50-DIO dynamic digital I/O, NT5000 ROM Emulator, GT40-RFS 200MHz Multiplexer, GT614-SM high density switch matrix, GTXI instrumentation chassis, and more. Call for your free copy. Geotest/Marvin Test Systems, Inc.; Tel: 888-TEST-BY-PC (837-8297) or 714-263-2222; www.geotestinc.com

Geotest/Marvin Test Systems, Inc.

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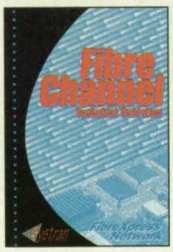

NETWORK FOR DSP APPLICATIONS

Introducing FibreXpress®, SYSTRAN Corp.'s new line of Fibre Channel host bus adapters. FibreXpress is ideal for very-high-speed mass storage and high-throughput, data-intensive DSP applications such as radar, sonar, medical scanners, and OCR. Request your free tech overview today! SYSTRAN Corp.; Tel: 937-252-5601; Sales: 800-252-5601; Fax: 937-258-2729; e-mail: info@systran.com; WWW: http://www.systran.com

SYSTRAN Corp.

For More Information Circle No. 675

NEW INSTRUMENT AND DATA ACQUISITION CATALOG

Keithley Instruments offers its new 1999 Full Line Catalog and Reference Guide with over 700 pages of electronic test and measurement instrumentation and data acquisition hardware and software, including DMMS, electrometers, precision sources, voltmeters, and other products. Also included are PCI, ISA, PCMCIA, and IEEE boards with an array of software. This valuable reference guide features application examples, selector guides, and complete product specifications. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, OH 44139; Tel: 888-534-8453; Fax: 440-248-6168; www.keithley.com

Keithley Instruments, Inc.

For More Information Circle No. 676

PVD THIN FILM WEAR-RESISTANT COATING SERVICES

Balzers Tool Coating provides high-quality thin film tool and precision component wear-resistant coatings. Our Web site offers easy access to products, applications, key contacts, case histories, seminars, technical literature, and coating-center locations. Balzers Tool Coating: The world leader in thin film coating technology; Tel: 1-800-435-5010; Fax: 716-695-1995; www.btc.balzers.com

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For More Information Circle No. 677

John Glenn — Back In Space

Celebrate history in the making! This white cotton shirt features the official emblems from Glenn's first voyage on Mercury 6 in 1962 and his return to space this fall aboard the Shuttle Discovery.

Available while supplies last in children's sizes 10-12 or 14-16; adult sizes M, L, XL, or XXL. $15.95 each plus $5.00 shipping and handling. Mail payment to: *NASA Tech Briefs*, Dept F317 Madison Ave., New York, NY 10017 U.S.A. For credit card orders call (212) 490-3999

TECH BRIEFS

Hot Technology File

1999 Resource Guide for Design Engineers & Managers

To receive information FAST from any of the companies featured in this supplement, use the Fast Fax Information Form on page 33.

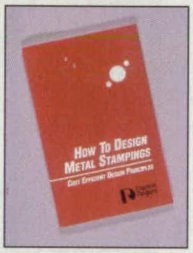
Supplement to NASA Tech Briefs *December 1998 Issue*

RGB Spectrum develops and manufactures products which integrate computer and video signals for display and communications. Products include the RGB/Videolink® video scan converters, the ComputerWall® multi-screen processor, the RGB/View® and SuperView® lines of real-time video windowing systems, the Synchro-Master® computer signal synchronizers, and other specialized scan converters and processors. External peripherals and VME boards. Applications include command-and-control, simulation and training, remote surveillance, video conferencing, large-screen communications, and virtual reality.

Contact Information:

RGB Spectrum, 950 Marina Village Pkwy., Alameda, CA 94501; Tel: 510-814-7000; Fax: 510-814-7026; e-mail: sales@rgb.com; www.rgb.com

Circle No. 759



How To Design Metal Stampings

This 40-page guide gives you design information as it relates to tolerance; blank size and layout; holes and openings; spacing of holes and openings to each other; the contour and relationship to forms; position and heights of forms; edge condition of formed parts; specification and characteristics of formed and drawn parts; limits of burrs and flatness; dimensioning practice for turret press, press brake, and laser; and charts on related subjects.

Contact Information:

Dayton Rogers Manufacturing Co., 8401 West 35W Service Drive, Minneapolis, MN 55449; Tel: 800-677-8881; www.daytonrogers.com

Circle No. 767

New 1998 Motion Control Supplement

This supplement to Newport's 1997/98 Motion Control catalog introduces exciting new product offerings. Included are: the ESP6000, a PC-based Motion Controller; the UNIDRIV6000 multi-axis universal motor driver; motorized rotation stages; new linear motor driver positioning stage (MAT350); and the Dynamx300 dual-axis air bearing stage. Customized stage manufacturing is also featured for the OEM customer.

Contact Information:

Newport Corporation, 1791 Deere Avenue, Irvine, CA 92606; Tel: 800-222-6440; Fax: 949-253-1680; www.newport.com

Circle No. 763

ND's Specialty Coatings Division supplies specialized coatings, including paints, lubricants, and custom, high-performance finishes, to applicator companies that have dip-and-spin, spin-drain, flood, spray, or electrostatic processing capabilities. These custom-formulated products are used in a wide variety of applications, including automotive assemblies. The Specialty Coatings Division offers a complete line of coating products that provide one or more of the following features: Lubrication, Temperature Protection, Friction Reduction/Modification, and Corrosion Resistance.

Contact Information:

ND Industries, Inc., 1893 Barrett Road, Troy, MI 48084; Tel: 248-362-1209; Fax: 248-362-1730; e-mail: info@NDIndustries.com; www.NDIndustries.com

Circle No. 768

Astro-Med, Inc.

Astro-Med, Inc.

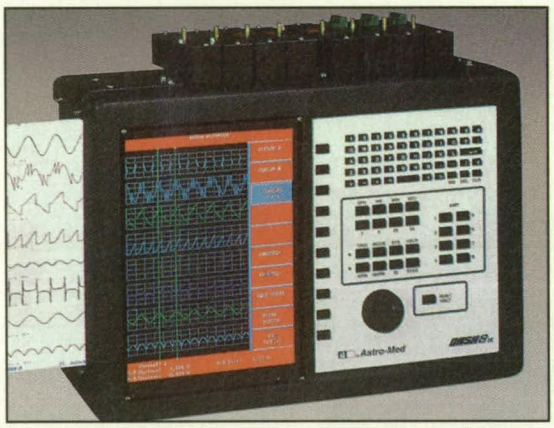
Astro-Med, Inc. is a leading supplier of specialty printer solutions to customers around the world. Astro-Med customers include leading aircraft manufacturers such as Boeing, Lockheed, McDonnell Douglas, and British Aerospace; automotive product manufacturers such as Chrysler, Ford, General Motors, Mercedes Benz, and Renault; telecommunications giants such as AT&T, NYNEX, and MCI; electrical utility companies including Northeast Utilities, Hydro Quebec, and Florida Power and Light; steel companies including USX, Posco, and Bethlehem; aluminum manufacturers such as Alcoa Reynolds; and paper manufacturers including International Paper, Kimberly-Clark, and Mead.

Astro-Med customers include Fortune 500 companies as well as small operations. They are located around the world, wherever there exists a problem that can be solved by an Astro-Med specialty printer.

Astro-Med specialty printers are total systems that display, monitor, analyze, and print data for aerospace, industrial, and medical applications. The machines, computer electronics, software, and consumables all are developed and manufactured by the company.

Examples of Astro-Med products include the MT95K2, which has become the world standard in chart recorders, especially in telemetry applications. Because of its power and versatility, the 32-channel K2 can perform a variety of tasks that previously required a battery of instruments. Other recorders from Astro-Med include the "Dash" line of portable units, which range from 2 to 30 channels. The recently introduced Dash 8u is an 8-channel recorder with universal inputs that features a 10.4-inch color LCD monitor, a 2-Gigabyte internal hard drive, and a 100-Megabyte removable Zip drive for data transfer and archiving.

At NASA in Huntsville, AL, Astro-Med recorders are used to capture important telemetry data.



New portable Dash 8u 8-channel recorder and data acquisition system with universal inputs.

Other Astro-Med products include portable paperless data acquisition systems. The AstroDAQ is a complete, ready-to-use system that can record up to 30 channels. The recently introduced AstroDAQ 2 is a very compact and lightweight version, especially suitable for portable field applications.

Astro-Med has also extended its technology to other specialty printers. The Tough Writer 2, a reliable, compact, ruggedized, high-speed PostScript page printer, is designed to withstand the rigor of military, airborne, shipboard, and industrial applications.

Astro-Med is a growth-oriented company that believes in vigorous new product development, in high-quality products, and in total customer satisfaction. Astro-Med's executive offices, R&D, and manufacturing facilities are located in West Warwick, RI and Braintree, MA. Astro-Med maintains sales and service offices throughout the U.S. and in London, Frankfurt, Paris, Milan, and Montreal. Astro-Med products are sold around the world by a combination of direct sales and service centers, and dealers, distributors, and representatives.

Astro-Med, Inc.
Astro-Med Industrial Park
West Warwick, RI 02893
Tel: 800-343-4039
Fax: 401-822-2430
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Circle No. 751

ANDOR
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ANDOR TECHNOLOGY LIMITED

CCD and ICCD Camera Systems for Spectroscopy & Spectroscopic Imaging

Andor Technology is one of the world's leading manufacturers of scientific CCD and ICCD camera systems. Renowned for their leading-edge performance, compact size, and ease of operation, Andor's systems are used for basic and applied research in leading universities, government institutions, and manufacturing organizations worldwide. The technology also has lent itself to sophisticated solutions for OEMs in various spectroscopy-related fields.

Founded in 1989, Andor Technology comprises a team of over 30 staff based at the company's modern administrative and production headquarters at Springvale, Belfast — site of Northern Ireland's new academic village. U.S. Sales and Technical Support Offices are sited in Connecticut and New Jersey.

A Comprehensive Range of Multichannel Detectors

Andor's products include CCD and intensified CCD (ICCD) multichannel detectors, and Raman spectrophotometers.

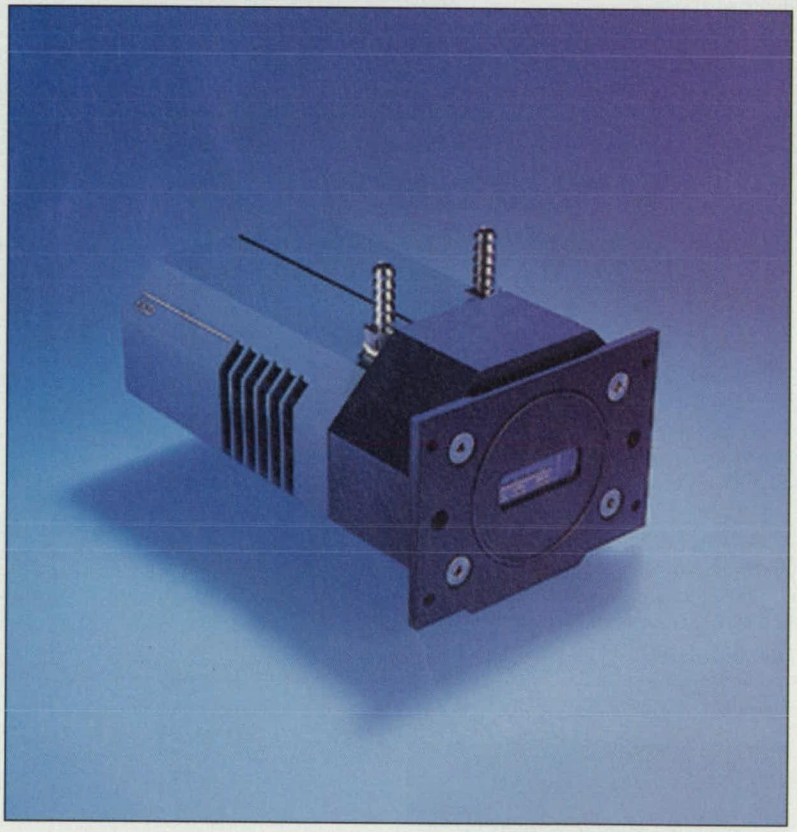
- Andor CCDs cover the spectrum from hard X-rays to the near infrared. Thermoelectrically cooled to -90°C for ultra-low dark signal, they offer outstanding performance for low-light measurement, easily handling exposure times from microseconds to days.
- Andor ICCDs are the choice for transient spectroscopy. Ultra-fast gating (<2ns optical gate width) and single photon sensitivity make them ideally suited to laser-induced breakdown spectroscopy, fluorescence lifetime measurements, fast plasma spectroscopy, and combustion studies.
- The RAMANSPEC spectrophotometer (available as a complete instrument or as a Raman engine for OEMs) performs non-contact, non-destructive analyses of solids, liquids, and gases in real time. Samples require minimal preparation and data are acquired with pushbutton simplicity.

Physical compactness, high performance, a user-friendly interface, and programmability (via the Andor Basic programming language), mean that Andor systems can be integrated into a multiplicity of experimental and industrial environments — ranging literally from research lab to space probe, from the study of morbid tissue to satellite re-entry phenomena.

Solutions Tailored to Individual Application Needs

Andor not only designs and manufactures CCD and ICCD cameras. Thanks to the broad spectrum of skills encompassed by its development and customer support teams, Andor is able to deliver complete system solutions. In-house, nearly half of Andor's staff is educated to post-graduate level in specialties such as optics, electronics, and software. These capabilities are complemented by a worldwide distributor network of sales engineers, who are regularly briefed to Andor's own rigorous standards. As a further assurance of quality solutions, Andor is accredited with ISO 9002.

Whether you are active in particle imaging velocimetry or laser ablation studies, spectro radiometry or spectromicroscopy (to name just a few of the areas in which Andor systems have been successfully deployed), chances are Andor will have the combination of hardware, software, and know-how to get the job done.



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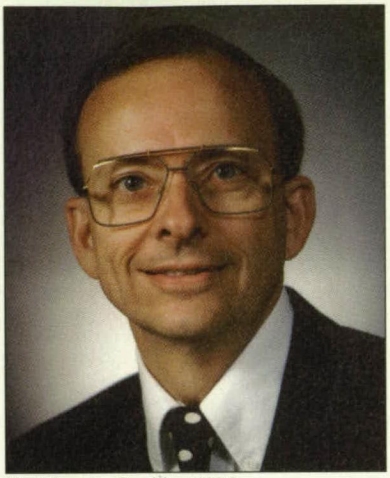
Circle No. 752

Digi-Key®



Mark Larson, President/COO

It started in 1972 — an idea, a new concept in distribution. Today, Digi-Key Corporation is one of the fastest-growing electronic component distributors in the United States. The concept that fueled this growth was to provide the highest level of service possible to Digi-Key's customers.

It all begins with the Digi-Key catalog. This 500-page technical resource, with more than 180 manufacturers represented, is updated and expanded every 60 days, reaching proven and prospective customers across the entire United States and Canada.

Once the phone rings, Digi-Key's leading-edge operational efficiencies go into effect. It continues with a computer system able to perform 24 million instructions per second and support 600 active. The customer is provided with real-time stock status and order entry, and instant access to hundreds of thousands of transactions.

From there, an intelligent conveyor system flawlessly routes orders through more than a mile of conveyor. From point of induction, orders are selectively diverted to each potentially relevant picking zone.

Once the order is filled, it goes to packing, where it is checked for accuracy and properly packaged. Then on to shipping, where the customer has more than 40 standard delivery options from which to choose.

This highly automated approach to order fulfillment allows orders to be processed — from order entry to shipping — in as little as 30 minutes! The end result of this kind of turnaround time is that orders placed by 5:00 p.m. Central time are shipped the same day! To ensure the customer of the absolute highest-quality standards, this entire process — from order entry to shipping — is ISO 9002 certified.

Digi-Key's certification is comprehensive, covering "the purchasing, warehousing, and distribution of electronic components, computer products, and accessories, including value-added assembly processes." This covers all facilities.

"ISO 9002 certification assures Digi-Key's customers that we have systems in place to provide them with a consistently high level of service," said Digi-Key President Mark Larson. "With audits required every six months to retain certification, it requires a sustained commitment to quality. To our customers, ISO 9002 certification means they will continue to get quality they can count on."

This commitment to quality service is confirmed by independent industry studies. Based on independent research conducted each year, Digi-Key rates:

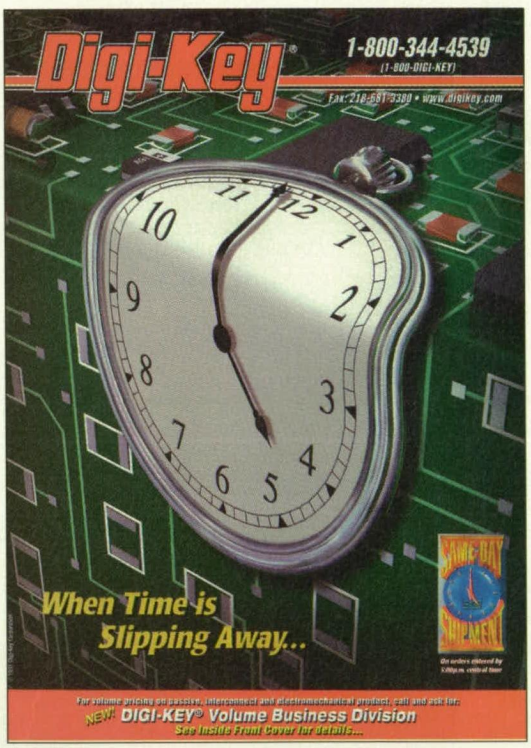
- #1 for delivery
- #1 for availability of product
- #1 for pricing
- #1 for responsiveness
- #1 for overall performance

In this qualitative industry report card, Digi-Key has earned the highest rating in all five categories, five years (1992-1996) in a row! When evaluated head-to-head with other distributors, Digi-Key is clearly the leader when it comes to service!

The word "service" is an easy one to throw around. In electronic distribution, everyone claims to be dedicated to service. But Digi-Key supports it with measurable performance that is confirmed time after time by simply asking our customers.

"We believe Digi-Key provides the best service in the industry," says Larson. "Our growth rate over the past 20 years and the industry studies are perhaps the strongest testimony to that fact."

Service is what differentiates one distributor from another. Service is what differentiates Digi-Key from other electronic component distributors.



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Circle No. 764

Breault Research Organization, Inc.

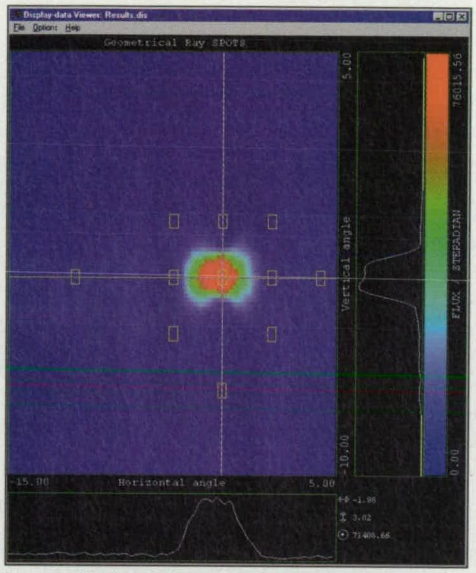
3-D Optical CAD Software

ASAP™ is a professional optical modeling program designed to calculate the performance of fully three-dimensional optical systems. It permits engineers to test their optical system by seeing what happens as light moves through the system. ASAP is uniquely suited to model advanced illumination, display, sensing and imaging systems.

ASAP is used independently or in conjunction with mechanical and lens design programs to construct three-dimensional models of optical systems. Lamps, arc sources, LEDs, or lasers can be placed anywhere within the geometry. Then, ASAP helps the user visualize the transfer of optical energy through the system as it is reflected, transmitted, absorbed, diffracted or scattered as it interacts with the system geometry.

Using ASAP enables you to reduce product-to-market time by simulating optical systems prior to prototyping and manufacturing and gets your optical engineering job done quickly and accurately.

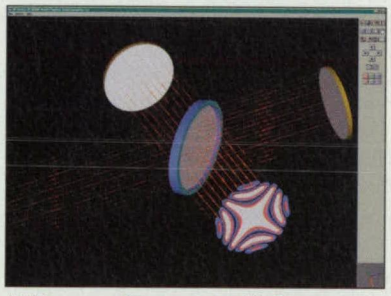
When considering an optical analysis program, remember: speed matters. An accurate illumination analysis often requires millions of rays to be traced. Traditional ray tracing codes can be tedious and time consuming. Everything about ASAP, a non-sequential ray tracing tool, is optimized for speed. With *ASAP/Basic* you can trace *millions* of geometric rays through a system in times ranging from minutes to a few hours. Rays can encounter surfaces in any order and any number of times. Rays can be traced forwards, backwards, continuously, or in steps.



The graphical analysis tools in ASAP show spatial or directional energy distribution anywhere in your system. This allows you to determine how your system is functioning and if it meets your specifications. Shown here is a sample radiant intensity output plot of a reflector and lamp subassembly.

ASAP is sold in modules to allow you to buy the exact capabilities that you need. Think of *ASAP/Basic* as the foundation, and add on modules from there depending on your project requirements.

The *ASAP/Basic* module includes everything you need to develop and analyze your illumination system. Build mechanical and optical systems consisting of up to 300 geometrical components. You can model everything from simple mirrors and lenses, to complex systems of imaging and light concentrating devices. Virtually any incoherent source can be modeled with the *Basic* module, from point sources, ray grids and fans, to detailed incandescent bulbs and high-intensity discharge lamps.



ASAP was used to construct this Twyman-Green interferometer. ASAP models coherent optical interference effects allowing the engineer to visualize and analyze optical systems that utilize coherent illumination.

Some of the other features in *ASAP Basic* include:

- Bulb catalog
- Radiant Imaging™ source import
- Spreadsheet style geometry and source builder
- Scripting language for macro building
- Scattered light modeling
- Multi-layer coatings
- Absorbing and gain media

The *ASAP/PRO* module allows for the rapid analysis of complex illumination systems and lets you model much larger systems (up to 3000 objects). Gives you the ability to add more geometry and spatial resolution to your analysis. A must if you are importing large mechanical CAD files into ASAP.

The *ASAP/Optical* module combines translators for popular lens design codes including SYNOPSYS™, Oslo®, CODE V®, and ZEMAX™ with the ability to analyze optical field propagation through your system. Analyze diffraction, coherent sources, and polarized light. Raytrace precision is increased with the inclusion of double-precision ray positions and directions and optical path length information is calculated and stored for each ray.

The *ASAP/CAD* module is for the designer who works closely with computer-aided-design tools. *ASAP/CAD* not only imports your CAD-based geometry, but optimizes the translation in such a way that ray trace speed remains high in spite of the increased complexity of the resulting parameterized surfaces. Includes a copy of the Rhino CAD program that allows the user to rapidly model and analyze complex optical systems. Combine *ASAP/CAD* with *Basic* and *PRO* modules and you have the best commercial analysis tool on the market for visualizing the performance of illumination systems.

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Circle No. 753

Software

WOLFRAM RESEARCH

An Extraordinarily Powerful, Unified Environment for Technical Computing

What is *Mathematica*?

Mathematica is the world's only fully integrated technical computing system, combining interactive calculation (both numeric and symbolic), visualization tools, and a complete programming environment.

Mathematica contains the world's largest collection of built-in special functions, designed to work both symbolically and numerically. Its unique automatic arbitrary-precision control tracks numerical uncertainty within calculations and adjusts numeric precision as needed. Standard abilities include Fourier and Laplace transforms, a powerful collection of matrix and tensor operations, optimization, root finding, and advanced curve fitting. Symbolic algebra capabilities allow you to perform integration, differentiation, and power series expansion, polynomial factorization and manipulation, equation solving, and closed-form solution of ODEs and many PDEs.

With *Mathematica*, you can produce 2D, contour, density, and 3D graphics, animations, and even sounds.

Mathematica notebooks are platform independent, combining into a single electronic doument format typeset mathematical expressions, formatted text, hypertext, and graphics, and customizable buttons and palettes. Typeset expressions in *Mathematica* notebooks are not frozen; they remain "live" and can be evaluated or used as input to a function.

An extensive help browser lets users find what they need quickly. The Help Browser includes the complete text of the latest edition of *The Mathematica Book*, Stephen Wolfram's definitive reference to the *Mathematica* system.

Mathematica is available for Windows NT, Windows 95, MacOS, UNIX, NeXTSTEP, and Linux.

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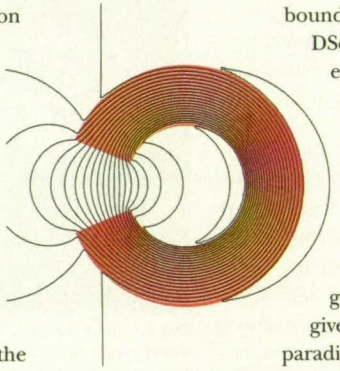
When on the hunt for a solution, which is the better approach to technical computing: numeric or symbolic? The answer, of course, depends entirely on the purpose of the calculation. A numeric calculation can provide valuable quantitative information, while a symbolic calculation can offer deeper insight into the meaning of the solution. The ideal technical computing environment, then, would allow the user to move quickly from one kind of calculation to the other, or even combine the two when necessary.

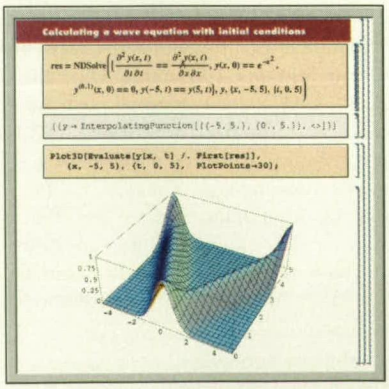


Mathematica® provides just such an integrated environment, but offers even more: powerful visualization tools; a flexible, intuitive programming language; and a complete technical publishing environment. The Mathematica user can create and optimize a model in symbolic form, and then use it to calculate numeric results of arbitrary precision.

Mathematica can manipulate expressions, scalars, vectors, matrices, and tensors of arbitrary dimension; and it operates in a consistent way, whether you are working with numeric data, symbolic expressions, or even a mixture of the two. The extraordinary set of built-in mathematical functions ranges from the elementary transcendentals to such specialized functions as those related to the Mathieu equation, the Legendre equations, and the hypergeometrics.

Mathematica's power to integrate both symbolically and numerically is simply unbeatable. *Mathematica* takes calculations that previously were prohibitively difficult, and makes them not only feasible but easy. DSolve and NDSolve can quickly solve a huge variety of differential equations, either symbolically or numerically to arbitrary precision. DSolve can solve all linear ODEs of any order with constant coefficients, and many linear equations with nonconstant coefficients, as well as a large fraction of the nonlinear ODEs. NDSolve can solve any ODE, stiff or nonstiff; specifying initial and boundary conditions is easy. DSolve can provide general solutions for linear and weakly nonlinear PDEs; NDSolve can do the same for linear and weakly nonlinear PDEs of the form 1+1 dimension.

Mathematica's programming language gives users the best of all paradigms, whether they are accustomed to procedural programming, functional programming, or list-based programming. Users can define functions to perform symbolic operations, numerical computation, 2D or 3D graphing, or to communicate with other processes or computers via the MathLink® protocol.



Wolfram Research's *Mathematica* Applications Library offers add-on packages extending *Mathematica*'s capabilities. Each contains a coordinated suite of functions and data types designed to provide tools valuable to a particular field.

Circle No. 754

Software

Autodesk. DESIGN YOUR WORLD™

Autodesk Software Brings Ocean Cinematography to New Levels

Hawkes Ocean Technology (HOT) dramatically cuts design-to-manufacture cycle time with Autodesk software.

Autodesk is the world's leading supplier of PC design software and PC multimedia tools. The company's 2D and 3D products literally are used to design the world around us, in industries including architectural and mechanical design, film making, videography, and geographic information systems. The fourth largest PC software company in the world, Autodesk has three million customers in over 150 countries. One of those customers, Hawkes Ocean Technology (HOT) is changing underwater cinematography.

HAWKES OCEAN TECHNOLOGIES

HOT was founded in 1996 as a wholly owned corporation to incubate creative engineering projects for specialty markets. The flagship technologies of the company are the revolutionary Deep Flight and Wet Flight—high-performance underwater submarines. Wet Flight is an innovative, one-person, wet (diver-scuba) submersible designed for underwater cinematography as a mobile camera platform. The performance of this craft exceeds all preceding wet submersibles, with sufficient power to fly through the water at relatively high speeds combined with minimal stability and extreme maneuverability.

Essentially, the sub has the agility of a dolphin energized by the power of a dozen thoroughbred horses to take the pilot on a motion charged ride that brings a whole new dimension to the art of underwater filmmaking and scuba diving. Not to mention the fact that the sub looks like a slick, underwater racecar. It's a very fast, lightweight underwater filming platform that travels at speeds up to seven knots.

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Trends for the Future?

Wet Flight will be used both on-camera as a prop, and off-camera as a filming platform. HOT's first lease was for an IMAX special project in June 1997, and the company anticipates that Wet Flight will become the filming platform and on-camera prop of choice for future underwater film/television projects. In addition, the vehicle may capture the interest of the scuba community. Therefore, future Wet Flights may be built for use by adventurous scuba divers. In addition, New Wave International, a film production company, used Wet Flight to create a film called "Dolphins, the Ride."

HOT Submersibles

While both Deep Flight and Wet Flight are similar crafts, the design approach for each was very different. "In the past, the engineering teams worked in a 2D realm only, using AutoCAD Release 14," says Eric Hobson, HOT mechanical engineering. "When we designed Wet Flight, we utilized a full suite of Autodesk tools. We entered the 3D world by implementing Mechanical Desktop for design and AutoVision and 3D Studio for visualization studies."

"A critical part of Wet Flight's design was obtaining visuals to assure that we were on track with the design. Throughout the design process, we were able to quickly obtain 3D models and renderings that accurately represented what the completed design would look like. We applied various colors and other attributes directly on the computer model. In real-time we could make design decisions on the fly. For us, this capability was a milestone."

Hobson says the computer renderings closely mirror the prototype created in the shop. The design team built the sub's frame, floatation, and wings in-house. "In the design of Wet Flight, we knew exactly what attributes and components we wanted to include in the sub. Using Mechanical Desktop, it was incredibly easy to export the Deep Flight AutoCAD files into Mechanical Desktop. I imported all the components, added an anatomical dummy to depict a pilot, and then designed a frame around all the elements. This is invaluable in creating the part as quickly and inexpensively as possible. That's not possible in the 2D environment."

Productivity Gains

Using Mechanical Desktop, the Wet Flight team designed and produced the innovative sub within just four months. Considering there are only five HOT employees, that's quite an engineering feat. Hobson adds, "Using Mechanical Desktop helped us adhere to our tight production schedule. Designing in 3D in real-time was a strong advantage on this project."

Circle No. 772

Software

ALGOR®

Scientists Use Finite Element Method in Developing New Cancer Detection Technique

By Dr. Jonathan Ophir, Professor of Radiology

A variety of techniques are used, including x-rays, ultrasound, biopsies and physical examinations, to detect tumors and determine which are malignant or benign. The most accepted and sensitive means for detecting breast lesions, for example, is with x-ray mammography. While this method is sensitive for detecting lesions, only about 20% of those identified by mammography are found to be cancers when biopsied.

Reducing the number of unnecessary biopsies is an important goal in breast cancer management. The average biopsy costs between $2,000 and $3,000 and causes considerable stress to patients. Given the cost and trauma associated with surgically sampling all cases where patients had mammographically detected lesions, there is a strong incentive to develop additional non-invasive methods to accurately determine if a lesion is benign or malignant.

Researchers are working on just such a technique that relies on ultrasound imaging. They call it elastography and it uses ultrasound to detect lesions and tumors and helps doctors determine whether they are malignant or benign. Elastography images the strains induced in the tissue as a result of a small external mechanical compression. To develop this imaging technique, researchers have employed a valuable modeling and analysis tool from the computer-aided engineering (CAE) field: the Finite Element Analysis (FEA) software of Pittsburgh-based Algor, Inc.

Tissues and Tumors

The elasticity of soft tissue depends to a large extent on its molecular building blocks (fat, collagen, etc.) and the microscopic and macroscopic structure of these blocks. In the normal breast, for example, glandular structures may be firmer than surrounding connective tissue, which in turn is firmer than subcutaneous fat. The standard medical practice of soft tissue palpation (examination by touch) to search for lumps is based on the qualitative assessment of tissue stiffness and the fact that certain pathologic conditions, such as malignant tumors, often manifest themselves as changes in the tissue's mechanical properties. But in many cases, despite stiffness differences, the small size of a pathological lesion and its location deep in the body, or both, prevent detection and evaluation by palpation or other techniques.

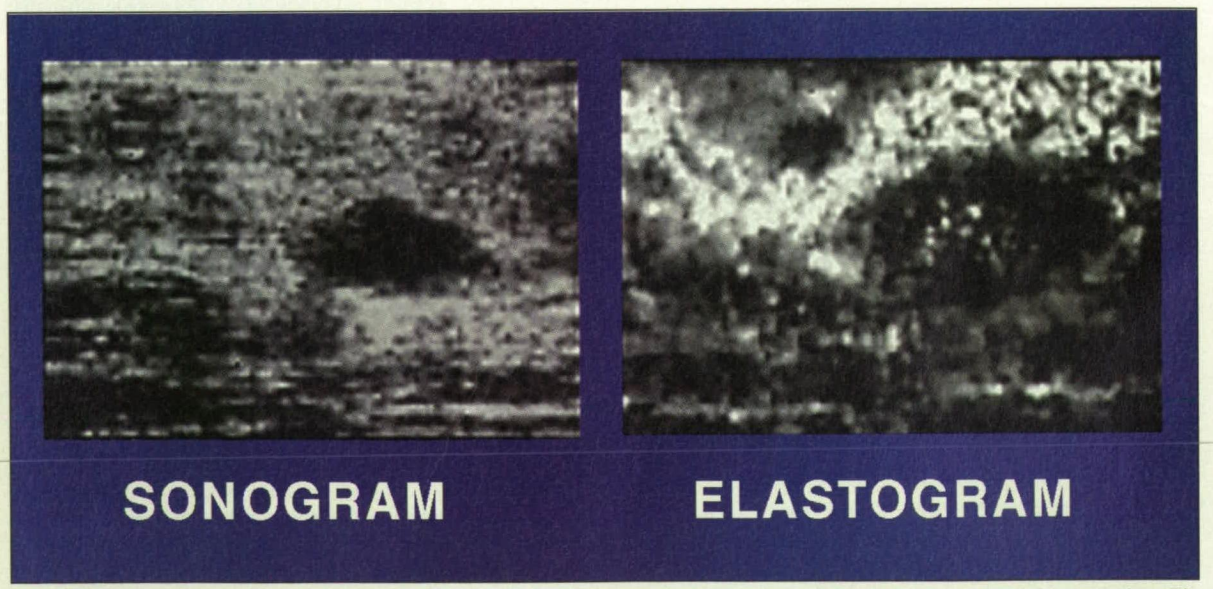
How Elastography Works

Tissues deform slightly when a small displacement is externally applied. Tissues that are more elastic deform more than tissues that are harder or less elastic. These internal deformations show up on elastograms, letting doctors assess the hardness or stiffness of tissues and decide whether or not there is a tumor in the imaged tissue. If a tumor's elastic properties are fairly uniform throughout, it tells doctors the tumor is benign. Cancerous tumors, on the other hand, grow in a very disorganized way. Therefore, malignant tumors have elastic properties that vary from one area to another, which should also show up on the elastogram.

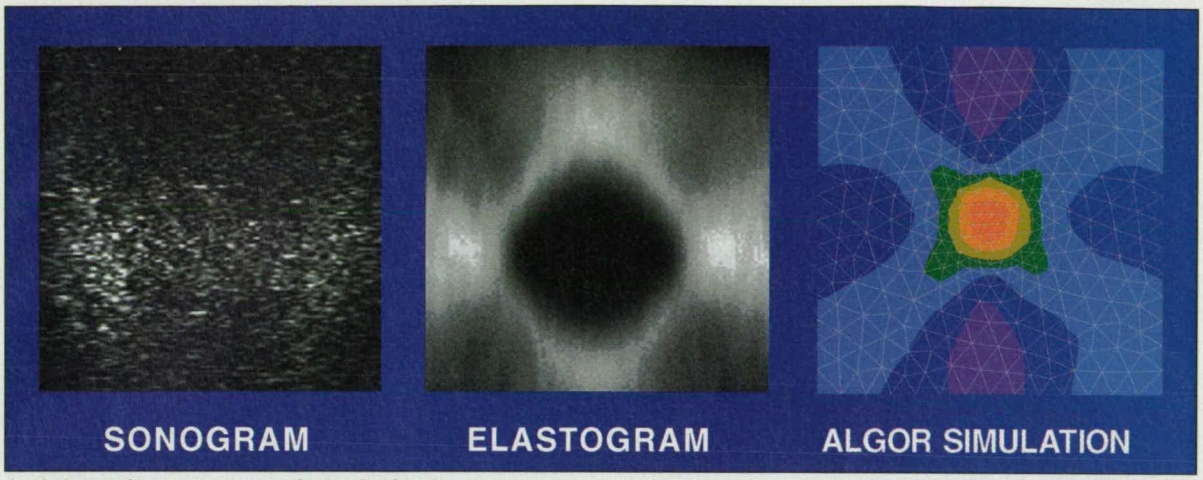
To create an elastogram, two ultrasound images of the same breast tissue are taken: one of the tissue in its normal, uncompressed state, and another when the tissue is slightly compressed. These images are compared point-by-point using signal processing algorithms to determine how the tissue elements moved when compressed, then converted into an image or elastogram.

Using FEA to Develop Elastography

To make sure the technique works on different types of tumors



The sonogram and the corresponding elastogram of a breast were taken simultaneously from the identical anatomical site volunteer patient. The sonogram shows the presence of a solitary hypoechoic (dark) lesion. The elastogram shows the same lesion as being hard and larger, most likely due to desmoplasia that causes hardening only around cancerous lesions. It also shows a soft core, suggestive of a necrotic center. Additionally, a second small (~6mm) lesion is detected on the elastogram at 10 o'clock relative to the main lesion. This anatomical structure is not visible on the sonogram. The elastogram's ability to display the smaller lesion demonstrates its capability of detecting tumors in the earlier stages of development.



A gelatin test object contains an inclusion that has the same ultrasonic properties as the surrounding medium, but is three times harder. The sonogram (left) does not detect the presence of the inclusion, while the elastogram (center) demonstrates it well. The bright region centered on the inclusion in the elastogram is a stress-concentration artifact predicted from the Algor software simulation of the sample at a 45 degree angle (right). (Test object courtesy of Dr. T. Hall from the University of Kansas Medical Center.)

in various locations, researchers created and imaged simulated tumors with varying conditions: from a malignant tumor near the chest cavity to a cyst near glandular tissue. These models are processed to create a simulated elastogram, letting doctors determine whether they could use the new method to detect tumors in those situations. While it might be more accurate to use human subjects rather than computer models, it would be nearly impossible to find people with all the necessary combinations of tumors and body locations for testing.

For each hypothetical placement of tissue the researchers wish to study, Algor's Superdraw is used to create a 2-D computer model of the tissue in its normal state. Building and analyzing three-dimensional models for this application does not offer significant advantages because elastograms are two-dimensional. Automatic meshing quickly prepared the models for analysis. Since elastograms render all areas of a sample with the same resolution, there's no need to refine meshes even in areas of interest.

With a standard mechanical hydraulic-testing apparatus, researchers determined the material properties of real breast tissue including muscle, fat, glandular tissues and various types of lesions. Data from real-life tests of breast tissues are made available to the FEA's linear stress processor.

Typically, tissue models are compressed about one percent. This is done by applying fixed boundary conditions and boundary elements to simulate pressure. Algor's linear stress analysis software then determines stresses, deflections and strains.

While most design engineers are interested in stress values from the analysis, those developing elastography look at displacements and strains in a model to predict what an elastrogram of that tumor/location combination will look like.

From the analysis, researchers determine if it will be difficult for doctors to detect a tumor in a particular tissue arrangement using elastography. If so, they perform real-life testing on gelatin models constructed to imitate the hard-to-image lesions and breast tissues. Comparing results of the finite element analyses on models with elastograms of gelatin test objects lets researchers optimize the procedure and develop new software algorithms that better display strain.

Although still in an early stage, the initial results of this clinical work are promising. Researchers have identified several possible indicators for distinguishing between benign and cancerous lesions. In the future, the researchers will try using elastography to detect and evaluate other kinds of cancer, particularly prostate cancer. Currently, two diagnostic methods are used to detect prostate cancer: digital rectal examination and traditional sonography. Even with these two detection options, however, a large number of prostate cancer cases go unrecognized. Successful cancer treatment will still depend on early detection and evaluation.

Additional contributors:
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Dr. Thomas Krouskop, Baylor College of Medicine in Houston
Dr. Michael Insana, Professor of Radiology, University of Kansas Medical Center

Algor produces premium mechanical engineering tools for Virtual Prototyping based on the finite element method. Scientists have used Algor to research the biomechanics of conditions, such as scoliosis, and develop medical devices such as biopsy needles and dental implants. Engineers in the aerospace, automotive, medical and consumer products industries use Algor to develop designs in less time at lower costs. More than 16,000 scientists and engineers located in over 60 countries use Algor's finite element analysis, Mechanical Event Simulation for Virtual Prototyping, CAD interfacing and piping analysis software. In addition, the Algor Publishing Division offers books, videos and multimedia products which help engineers do better design, simulation and analysis with virtually any engineering software.

For more information, contact Algor, Inc., 150 Beta Drive, Pittsburgh, PA 15238-2932; Tel: 412-967-2700; Fax: 412-967-2781; e-mail: info@algor.com; www.algor.com

Circle No. 757

Software

RAND™ WORLDWIDE

Let Knowledge be your guide.

PROCISION™

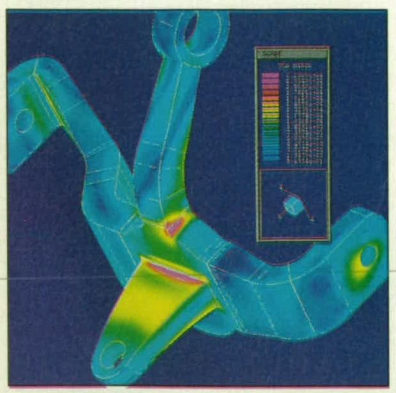
Speed

PROCISION™ can analyze very complex models using only several hundred degrees of freedom. Instead of solving tens of thousands of simple equations, PROCISION uses a small set of very complex special functions that consider the entire volume of the part. Today's P-Element and Boundary-Element products provide a system that is easier to use than traditional H-Element solvers, but at the expense of huge computer resource requirements.

The current release of PROCISION 3.1 provides the following types of analysis: linear static, steady state thermal, and vibration (modal, dynamic time response, frequency response, and random response).

Rand Worldwide™

Rand Worldwide provides the exclusive worldwide distribution, training, and support for PROCISION. Rand Worldwide is the world's largest reseller of advanced design automation technology. We are the largest provider of Parametric Technology Corporation's Pro/ENGINEER® and we supply a suite of its best complementary products. Rand has been selling analysis products to Pro/ENGINEER users for nearly ten years. We believe that PROCISION will finally allow engineers to easily analyze their most complex models right within the Pro/ENGINEER environment.



What is PROCISION™?

Solids Based Analysis

For many years, analysis software vendors have been promoting their products as easy to use, fast, and accurate. However, few of these products have delivered the productivity gains expected. Users are still required to de-feature complex models, partition solid models into small elements, and use enormous computer resources. Today's analysis tools are based on technology developed back in the early 80s.

Rand Worldwide has now brought a revolutionary new product called PROCISION to the analysis market. This system is the first to use a precise solids model foundation. With its initial roots in Eastern Europe, it uses a set of new mathematical techniques that have been under development for over 15 years. PROCISION has been recently developed to perform structural analysis directly on precise solid models.

No Mesh

PROCISION runs entirely inside the Pro/ENGINEER environment and requires absolutely no finite element or geometric element mesh. It uses the precise Pro/ENGINEER part surfaces for the analysis model. Complex surfaces, fillets, and small details need not be removed. PROCISION is also able to include both thin-walled and solid sections in the same model. Loads and boundary conditions are applied using Pro/ENGINEER menus and are directly associated to surfaces, edges, and datums. Large changes are easily made to the model because there is no mesh to recreate.

Reduction in System Resources

Memory and scratch disk space required to analyze complex models are orders of magnitude (from 10 to 100 times) less than in traditional H-Element, P-Element, or Boundary-Element products.

Stress Concentrations

Calculating the correct values and locations of small local stress concentrations is one of the most difficult tasks for engineers and analysis software. These areas are very small, and typically, unless a very fine mesh is placed at the right location, the solutions will not be accurate. PROCISION can automatically calculate very accurate stresses due to the local effects of these geometric features without using a mesh. PROCISION finally eliminates the guesswork and long solution times of traditional methods.

Unique Post Processing

After a solution is achieved, PROCISION is able to calculate results for any x,y,z point either on the surface or inside the solid model. It is not limited to averaging the calculated values of predetermined elements. This provides the ability to display results with extreme precision. Post processing graphics enable fast, interactive manipulation. Graphs showing stress and displacement results along part edges or any curve between two points can be displayed. Precise shaded models of deformed shapes are displayed for both vibration mode shapes and static deflections.

Animation is available for Structural and Vibration analysis. For Time Response analysis, it is possible to watch development of the solution in time using the Movie option. This option provides engineers with a complete picture of wave propagation in the structure.

Circle No. 778

RAND WORLDWIDE

Let Knowledge be your guide.

AUTOMATION GATEWAY™

Product Highlights

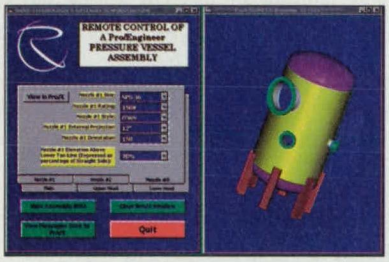
Communicate directly from Excel®, Word®, Access®, or any application that supports ActiveX®, directly to Pro/ENGINEER® using Rand Automation Gateway™.

Client/Server environment — Send and receive information to and from Pro/ENGINEER on remote machine.

Windows® applications developed using Automation Gateway can be linked to Pro/ENGINEER sessions running on either Windows NT or UNIX.

Two-way communications with Pro/ENGINEER.

Increased flexibility in customizing Pro/ENGINEER.



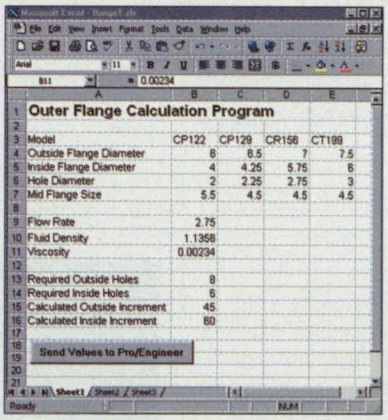
Rand Worldwide
Tel: 877-RAND-AID
www.rand.com

What is Automation GATEWAY™?

Automation Gateway allows any application that supports ActiveX to be configured to communicate directly to Pro/ENGINEER. Using Visual Basic®, standard Microsoft Office® products such as Word, Excel and Explorer can be utilized to exchange data with Pro/ENGINEER objects. Custom user interfaces can be developed for Pro/ENGINEER so specific tasks can be automated or full automation systems can be created.

Front End Application + **The Gateway Technology** + **Library of Configurable Pro/E Models** = **An Easily Developed Automation Solution**

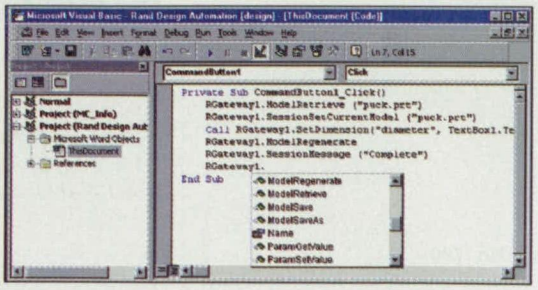
Pro/ENGINEER is an excellent tool for building configurable, reusable models. With Pro/ENGINEER alone the design logic that defines these models can exist only within the models themselves. By combining Automation Gateway with a library of Pro/ENGINEER models, design rules previously captured within Pro/ENGINEER, objects can now be moved to external applications. This creates a more flexible and maintainable environment for business design logic.



	A	B	C	D	E
1	**Outer Flange Calculation Program**				
2					
3	Model	CP122	CP129	CR158	CT199
4	Outside Flange Diameter	8	8.5	7	7.5
5	Inside Flange Diameter	4	4.25	5.75	6
6	Hole Diameter	2	2.25	2.75	3
7	Mid Flange Size	5.5	4.5	4.5	4.5
8					
9	Flow Rate	2.75			
10	Fluid Density	1.1358			
11	Viscosity	0.00234			
12					
13	Required Outside Holes	8			
14	Required Inside Holes	6			
15	Calculated Outside Increment	45			
16	Calculated Inside Increment	60			
17					
18					
19	Send Values to Pro/Engineer				
20					
21					

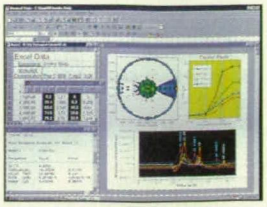
Examples

- Send values from Excel spreadsheet directly to Pro/ENGINEER dimensions or parameters.
- Automate Pro/ENGINEER session from Visual Basic program.
- Use Word as data input screen to Pro/Program or Pro/Notebook.
- Create design utilities in Visual Basic.
- Transfer data directly between Access database and Pro/ENGINEER.
- Create custom interfaces to Pro/ENGINEER so non-Pro/ENGINEER users can configure Pro/ENGINEER models.
- Retrieve mass property information directly from Pro/ENGINEER models into Excel spreadsheet for calculations.
- Combine Microsoft Office with the power of Pro/ENGINEER.



Circle No. 779

Software



Origin™ 5.0 32-Bit Version

An advanced technical graphics and data analysis software that includes 3D and contour plotting for Windows 95 and NT 4.0. Features include the ability to open and use Excel™ workbooks inside Origin, drag-and-drop plotting, embedding of Origin graphs using OLE2, FFT filtering, a new notes window, and easy-to-use multi-tabbed dialog boxes. All features of the plots and worksheets created in Origin can be easily customized.

Contact Information:

Microcal Software, Inc., One Roundhouse Plaza, Northampton, MA 01060; Tel: 800-969-7720 or 413-586-2013; Fax: 413-586-0126; e-mail: info@microcal.com

Circle No. 755

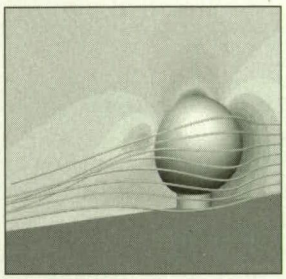
General Aviation Computer-Aided Design Software

G.A.-CAD is a preliminary design system for general aviation airplanes and small business jets. G.A.-CAD allows design engineers to rapidly evolve an airplane configuration from weight sizing through detailed performance calculations and cost estimations, and incorporates Aero-CADD, a fully functioning, three-dimensional wireframe and surface modeling software for airplane drafting and design.

Contact Information:

DARcorporation, 120 E. 9th, Suite 2, Lawrence, KS 66044; Tel: 785-832-0434; Fax: 785-832-0524; info@darcorp.com; www.darcorp.com

Circle No. 765



Amtec specializes in software for the visualization of scientific and engineering data, and for the numerical simulation of fluid flows. The company develops and markets Tecplot, a comprehensive plotting and visualization package; INCA, a computational fluid dynamics (CFD) package for analyzing a wide range of two- and three-dimensional fluid flow fields; and CFDAnalyzer, a point-and-shoot application for simplifying common CFD analysis tasks.

Contact Information:

Amtec Engineering, 3055 112th Avenue NE, Suite 100, Bellevue, WA 98004; Tel: 425-827-3304; Fax: 425-827-3989; www.amtec.com

Circle No. 782

Meadowlark Optics' Achromatic Waveplates

Our Achromatic Retarders are designed to provide a retardance accuracy of $\lambda/100$ over a broad spectral range (several hundred nanometers). Better field of view than quartz, and available in quarter and half wave at a variety of broadband ranges. Precision made by highly skilled technicians, these Achromats hold to tight specifications to provide the quality you need. Call or e-mail for a free catalog.

Contact Information:

Meadowlark Optics, 7460 Weld County Road 1, Longmont, CO 80504; Tel: 303-776-4068; e-mail: sales@meadowlark.com

Circle No. 760

Innovative Optics Technology

Since 1886, Pennsylvania Optical, a division of ORC Electroformed Products, has specialized in manufacturing innovative optics technology for industrial, military, and scientific applications. Advanced systems, including custom optical components, sub-assemblies, and precision lenses, are engineered to give man and machine the vision to perform their tasks more accurately and efficiently. Literature presents distinctive technology, quality control, product engineering, and fabrication solutions to meet any challenge.

Contact Information:

ORC Electroformed Products, 1300 Optical Drive, Azusa, CA 91702; Tel: 626-915-3053; Fax: 626-815-3051.

Circle No. 780

Polymicro Technologies, Inc. is a manufacturer of multimode, step-index fused silica optical fiber with polyimide, silicone, acrylate, and aluminum buffers; solarization-resistant optical fiber; fiber-optic cables and assemblies; high-strength, high-temperature flexible fused silica capillary tubing; square capillary tubing; UV transparent capillary tubing; micro-components; and multilumen tubing.

Contact Information:

Polymicro Technologies, Inc., Sales Department, 18019 North 25th Ave., Phoenix, AZ 85023-1200; Tel: 602-375-4100; Fax: 602-375-4110; e-mail: sales@polymicro.com; www.polymicro.com

Circle No. 783

LSI

Laser Science, Inc.

A Subsidiary of Thermo Vision

Company

Laser Science, Inc. designs, manufactures, and markets a variety of compact lasers, dye lasers, and doublers, providing sources of low-cost laser light from UV through IR. Scientists in biotechnology, chemistry, physics, and environmental research are the primary users of our products.

Laser Science, Inc. was founded in 1981 as a government contract research house. We produced laser-based atmospheric remote sensing and optical communication systems for government agencies. As defense funds diminished, we made a successful transition into commercial markets. At present, more than half of our production goes to OEM (original equipment manufacturer) accounts. Our lasers are incorporated into instruments for MALDI-TOF mass spectrometry, drug screening, medical diagnostics, and other laser-based measurement technologies. Thermo Vision Corporation, part of the Thermo Electron Corporation group of companies, purchased Laser Science, Inc. in 1997. Thermo Vision Corporation is an emerging leader in the worldwide, multi-billion-dollar photonics market.

Products

UV. Laser Science, Inc. is the world's leading supplier of pulsed nitrogen lasers delivering radiation at 337 nm. We offer the research-oriented VSL-337ND-S and the ultra-compact VSL-337 in addition to a number of OEM models.

Visible through Near-IR. We designed nitrogen pumped dye lasers for output from 360 nm to 950 nm. Choose between fixed frequency and tunable models.

Deeper UV. The visible output of our dye laser system is doubled into the UV with our new doubling module. Select radiation from 220 nm to 320 nm.

IR. Our new, compact μTEA CO_2 laser supplies pulsed laser radiation at 10.6 μm in the IR.

Laser Accessories. We developed adapters to couple our nitrogen and dye laser systems to many commercial microscopes for both full field illumination and focused beam experiments. We offer a number of other accessories including fiber optics, pulse generators, and detectors.

Lasers In Action

Researchers in many fields of science use our lasers in a variety of ways. We offer economical pulsed laser light from the UV through the IR with nitrogen lasers at 337 nm, nitrogen pumped dye lasers covering 360 nm to 950 nm, doubled dye output from 220 nm to 320 nm, and our new μTEA CO_2 laser at 10.6 μm in the IR. Our lasers feature sealed plasma cartridges. They are compact, rugged, reliable, and tolerant of many environmental extremes.

Application areas include fluorescence imaging, fluorescence immunoassay, ablation or microsurgery of biological samples, photochemistry, caged compound release or photolysis, micro-CALI (chromophore-assisted laser inactivation), capillary electrophoresis detection, and medical diagnostics.

We apply technical expertise gained from our experience in building complex systems for government agencies to meeting the needs of our current customers. Laser Science products are operating under the Antarctic ice and we are working on a space-hardened laser. This practical knowledge is then applied to improvement of our commercial and OEM products. We encourage potential customers to discuss their needs with our staff.

Laser Science, Inc.
Tel: 508-553-2353
Fax: 508-553-2355
www.laserscience.com

Circle No. 766

Photonics

Newport®

Newport Corporation introduces its new line of Tunable External Cavity Laser Diodes and Wavelength References. The 2010 Series of CW tunable lasers has been designed with a simple philosophy in mind: to offer the end-user the ideal combination of cutting-edge performance at the most reasonable cost.

ECU-2010 Stabilized Light Source

The ECU-2010-STAB-1550 is an absolute optical frequency reference source designed for use as a calibration tool in dense wavelength division multiplexing (DWDM) applications. The source contains an external cavity diode laser, which is locked to either the absorption lines of acetylene or hydrogen cyanide providing reference lines at 30GHz intervals across the entire 1550nm window. The long-term stability is better than 1MHz and every cell is traceable to National Institute of Standards and Technology specifications.

ECU-2010 Tunable Laser

This tunable single-mode diode laser based on a Littman-Metcalf cavity now offers over 20 different diode modules, allowing the user to scan from 632nm to 1780nm. Changing wavelength ranges involves only the switching of a self-aligning module, taking no more than a few minutes. This inexpensive laser combines narrow linewidth operation and a wide continuous tuning range, resulting in cutting-edge performance at an entry-level cost. Both free-space and fiber output versions are available. Applications include laser seeding, process control monitoring, medical diagnostics, and fiber-optic testing.

L2010 Lockbox

This dual servo unit was designed to work with the 2010 tunable laser to lock the laser frequency to absorption lines. The user has a choice of using a dither lock to find the center of an absorption line or a DC differential lock to find the edge of a transmission line. This instrument was designed for researchers who need the ultimate in frequency stability, attaining linewidths of 100kHz.

ECU-2010 Wavelength Reference Standard

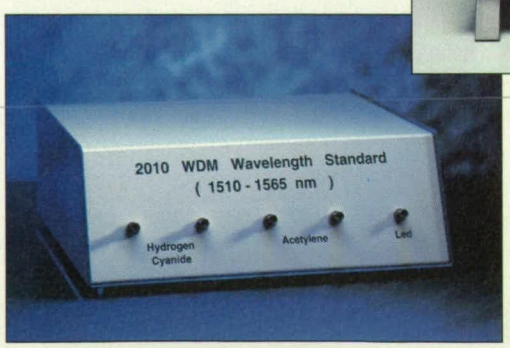
This unit is designed to calibrate optical spectrum analyzers, tunable lasers, and wavelength meters in the complete dense wavelength division multiplexing (DWDM) window. It uses two absorption cells, acetylene and hydrogen cyanide, providing calibration lines from 1520-1560nm. The cells are coupled to single-mode fibers with a transmission loss of less than 1dB. An extremely low ripple, fiber pigtailed, superluminescent laser diode is built into the system and can be coupled out directly or through either one of the two absorption cells.

ECU-2010-OEM Wavelength Reference Standards

These absorption reference standards are based on single-mode fiber coupled acetylene or hydrogen cyanide reference cells. Their primary use is in Optical Spectrum Analyzers, fiber-optic test stations, and telecommunication transmitters as in-situ, absolute frequency reference sources. The cells exhibit a transmission loss of only 1dB and have been leak-tested and temperature-cycled.

Spectral Reference Cells

We offer a complete line of individual spectral reference cells for atomic absorption spectroscopy and fiber-optic testing. These include rubidium, cesium, and potassium cells, and acetylene and hydrogen cyanide cells.



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1791 Deere Avenue
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Circle No. 762

Photonics

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We're here to make your life simpler!

We offer a wide selection of lasers, optics, opto-mechanical equipment, and optical instrumentation that will enable you to carry on your research, development, and prototyping with ease.

To provide you with rapid delivery, our products are held in stock in both the USA and Europe. If you need production quantities, we would like the opportunity to provide you with a custom quotation.

Coherent factories in the USA and UK are experienced manufacturers of high-performance optical component and opto-mechanical equipment and instruments.

We are constantly expanding our product lines and catalogs for your convenience. Please look to our website, www.catalog.cohr. com for the latest innovations and informaiton about Coherent.

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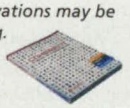

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Circle No. 773

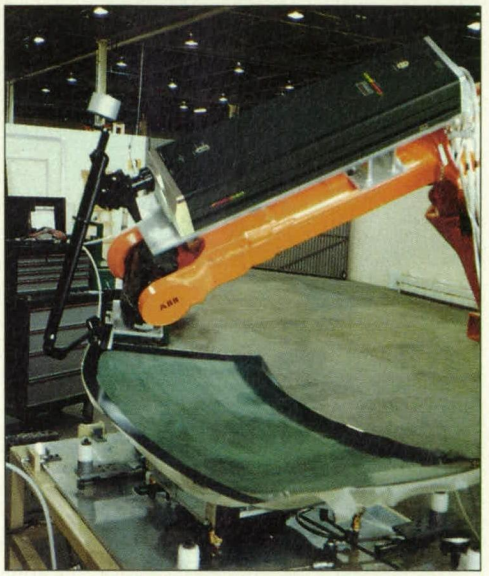
Photonics

SYNRAD

Laser Technology for Industry

Since its start in 1984, Synrad, Inc. has come to be recognized as a leader in the development of sealed CO_2 lasers and electro-optic technologies. Founded by Peter Laakmann, who pioneered the RF-excited CO_2 laser, Synrad has delivered more CO_2 lasers to industry than any other manufacturer. Currently, Synrad lasers cut, mark, drill and perforate a multitude of materials in over 20,000 installations worldwide. In August 1998, Synrad was acquired by Excel Technology. Excel and its subsidiaries develop, manufacture, and market laser systems and electro-optical components for electronic, semiconductor, other industrial, scientific and medical applications.

Synrad's extensive Applications Laboratory is available for processing trials and feasibility studies.



Synrad designs its lasers to integrate easily with machinery, such as robotic arms.

Synrad's goal is to design and manufacture a range of lasers that are easy to use, reliable, and affordable, and to open up new applications for sealed CO_2 laser technology. Synrad lasers, when combined with suitable optical assemblies, motion systems, and computer controllers, have countless manufacturing applications, and this number is growing, as new applications continue to be discovered on a daily basis. They are ideal in applications involving drilling, cutting, and marking on steel, plastic, wood, paper, fabric, and other organic materials, replacing cumbersome knives, saws, scribers, inkjet markers, and pen plotters.

Lasers offer a number of benefits over other technologies, including improved flexibility, less downtime, and long operating lifetimes. Synrad lasers feature the patented "all-metal" tube, which ensures high laser gas purity, and therefore, an exceptionally long operating lifetime — an excess of 35,000 maintenance-free operating hours can be expected from a Synrad laser before a simple gas refill is required. The durable metal tube enables the lasers to withstand harsh industrial environments, and, because the tube can be produced simply and inexpensively, a Synrad laser is very affordable.

Available with output powers from 10 to 600 watts, Synrad designs its sealed CO_2 lasers as components, to be easily integrated into machinery. The company offers a wide range of accessories that enable customers to configure their own system, including beam delivery components, focusing assemblies, and lenses. Synrad also manufactures the patented Power Wizard™ hand held laser power meter, laser controllers, a galvo-based digital marking head and WinMark Pro™ laser marking software.

A major supplier of laser marking systems and components, Synrad's rugged and compact DH Series Marking Head contains the latest fiber-optic and digital technology, which delivers high resolution and accuracy in tough manufacturing environments. Compatible with Synrad's 10 to 125 watt lasers, the DMH delivers crisp, permanent marks. Synrad's WinMark Pro software, the first Windows-based laser marking software, provides a user-friendly interface to laser marking. The ease of use and flexibility of this software make it ideal for marking alphanumerics, bar codes, and logos.

For any company considering the benefits of laser technology, Synrad offers a free process evaluation. Their extensive Applications Laboratory is well equipped to handle a wide variety of materials and applications. Send them a description of your current process, an example of a "finished" product, and some unprocessed samples. Your samples will be returned to you, suitably marked, cut, or drilled by Synrad's experienced applications staff, complete with a written materials evaluation, and additional information on implementing laser technology.

Acrylic, metal, wood, electronic components, and paper are just a few of the materials that can be cut and marked with CO_2 lasers.

Synrad, Inc.
6500 Harbour Heights Pkwy.
Mukilteo, WA 98275
Tel: 800-SYNRAD-1 or
425-349-3500
Fax: 425-485-4882
e-mail: synrad@synrad.com
www.synrad.com

Photonics

Circle No. 777

MELLES GRIOT

For 30 years, Melles Griot has been the world's leading manufacturer and distributor of optics, lasers, and electro-optic systems for science and industry. The highly respected Melles Griot catalog includes a wealth of technical and educational material, along with a comprehensive listing of products. It is used by engineers, scientists, and purchasing agents, in universities and colleges, not only as a purchasing guide but also as a supplemental teaching aid.

When Melles Griot releases the next catalog, it will include exciting new products (a few of which are described below), along with a standard offering of laboratory and OEM components. To request a catalog, call 1-800-835-2626 or e-mail mgsales@irvine.mellesgriot.com

High-power UV and violet lasers

Green diode-pumped solid-state lasers

Green Diode-Pumped Solid-State Lasers

Our LazerGuide™ and GMS-series lasers produce up to 50 mW of output at 532 nm in small, convection-cooled packages that can be run with standard laboratory power. These lasers have excellent TEM_{00} beam quality, very low noise, and long operating life (typically in excess of 10,000 hours). They are an ideal replacement for air-cooled argon-ion lasers in many applications. The LazerGuide is an environmentally sealed system designed specifically for applications in the harsh environment of a manufacturing floor or sawmill. GMS lasers are configured primarily for laboratory or OEM systems, and can be operated from a five-volt dc source. (For more information call 1-800-645-2737.)

Melles Griot
Electro-Optics, Instruments
4601 Nautilus Court South
Boulder, CO 80301
Tel: 1-800-326-4363
Fax: 303-581-0960
e-mail: 104147.2363@compuserve.com

Laser Group
2251 Rutherford Road
Carlsbad, CA 92008
Tel: 1-800-645-2737
Fax: 760-438-5208
e-mail: sales@carlsbad.mellesgriot.com

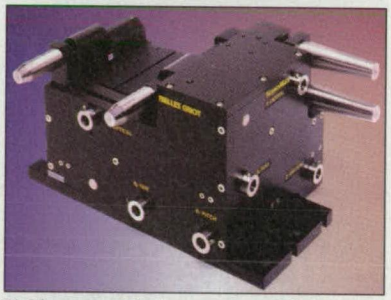
Photonics Components
16542 Millikan Avenue
Irvine, CA 92606
Tel: 1-800-835-2626
Fax: 949-261-5600
e-mail: mgsales@irvine.mellesgriot.com

High-Power UV and Violet Lasers

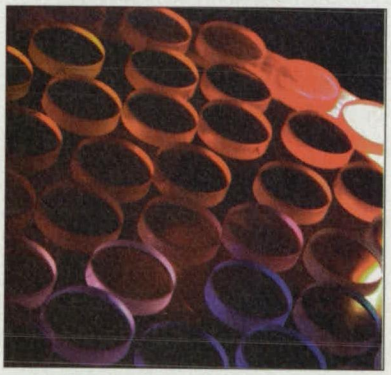
Our new line of LiCONiX high-power helium cadmium lasers produces up to 75 mW of ultraviolet output at 325 nm, or 215 mW of violet at 442 nm. These lasers are used extensively in three-dimensional stereolithography, disk mastering, holography, optical inspection, and biotech applications. Models are available with linearly polarized output for enhanced efficiency through modulators, high TEM_{00} mode purity for high resolution, and CE certification for worldwide use. (For more information call 1-800-645-2737.)

Rigid Nanopositioning Systems With Six Degrees of Freedom

These new modular nanopositioning systems extend the state of the art by eliminating the "wobble" and "flop" of conventional six-degree micropositioning systems. Typically, stages are mounted, one atop the other, to attain the required motion. With these new devices, a single mounting platform is rigidly contained by six linearly independent constraints, improving stiffness by an order of magnitude. The virtual mechanical pivot makes aligning single-mode fibers a snap. (For more information call 1-800-326-4363.)



Rigid nanopositioning systems with six degrees of freedom



UV high reflectors for excimer lasers

UV High Reflectors for Excimer Lasers

Melles Griot now manufactures precision high-energy ultraviolet laser mirrors on fused-silica and calcium fluoride substrates. These high reflectors (>99.9 R) are available at all major excimer laser wavelengths from 193 nm to 355 nm. (For more information call 1-800-835-2626.)

Circle No. 784

Technical Leadership in Positioning Systems, Motors, Drives and Controllers

In 1999, Aerotech completes 29 years as a leading supplier of motion control products and positioning systems to industry, research, educational, and government customers. The breadth of the company's product line — from high-performance plano air bearing systems to brushless linear servomotors and drives, to advanced, multi-axis motion controllers, to ultra-precise laser interferometer position transducers — makes Aerotech unique among motion control manufacturers. Aerotech's research and development investments are yielding leading technologies and innovative products that permit true advances in precision positioning systems.

Positioning Systems Division

Aerotech's advanced linear-motor-based mechanical and air bearing systems have found broad acceptance in a variety of semiconductor, flat panel display, imaging, laser machining, and general positioning applications. These highly advanced systems offer the submicron accuracy and extremely tight velocity control critical to today's most demanding processes. Aerotech also specializes in cleanroom and high vacuum systems.

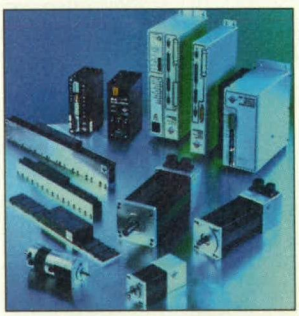
While our broad array of standard stages covers virtually all application requirements, for the few it doesn't, we can provide custom positioning systems and components for both OEMs and end users.

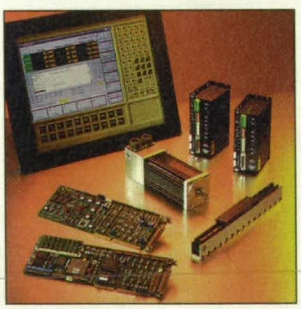
Drive Components Division

For years, Aerotech-manufactured motors and drives have been utilized in our own positioning systems and by discriminating end users and OEMs worldwide.

Brushless Rotary Motors and Drives. Our BM and BA series brushless rotary motors and drives offer the industry's highest torque-to-inertia ratio and provide speed and acceleration capabilities unavailable from equivalently-sized DC brush-type drives.

Linear Motors. Featuring the industry's highest output force-per-volume ratio, Aerotech "U-channel" and flat brushless linear servomotors and machining drives have proven themselves where it matters — in the field. With thousands of axes deployed in applications worldwide, our reputation for high reliability and superior performance is being earned daily. We are proud to offer our customers the industry's broadest array of standard "U-channel" model sizes and corresponding power ranges. But if you do not see a standard model that suits your application, custom motor and drive configurations are available for our OEM customers.





Machine Automation Division

From a single axis to 16 axes and more, Aerotech's motion controllers offer the features and flexibility to satisfy today's most demanding applications. Whether you prefer a PC-bus-based or a standalone controller, for high throughput point-to-point or complex multi-axis contouring, there is an Aerotech controller to do the job.

Because software defines an ever-greater part of the functionality of modern motion controllers, Aerotech devotes substantial resources to the development and support of powerful application software and versatile programming tools. For example, our PC-bus-based UNIDEX 500 and 600 motion controllers feature sophisticated man-machine interfaces built upon well-documented development tools.

Custom-Engineered Solutions

Throughout our history, Aerotech has developed many customized turnkey positioning systems to meet the special requirements of our customers, including many of the largest Fortune 500 companies. From concept to final certification, Aerotech's engineers and technical staff apply their expertise and skills, along with Aerotech's proven products and positioning technologies, to assure the success of our custom-engineered systems.

Worldwide Support, Local Convenience

Aerotech is fully committed to supporting its customers worldwide. We maintain a growing number of direct field sales and engineering offices throughout the U.S. In addition, we operate our own full-service facilities in the U.K. and continental Europe. This staff is augmented by additional Aerotech selling partners and integrators, strategically located in the U.S. and all the major manufacturing economies worldwide, to make available competent local customer support.

Visit Aerotech on the Web at www.aerotechinc.com for detailed product specifications, new product announcements, and up-to-date company news.

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Circle No. 761

Motion Control

Allen-Bradley
RELIANCE ELECTRIC
DODGE
ROCKWELL SOFTWARE

Rockwell Automation

Bringing Together Leading Brands in Industrial Automation

Integrate Motion and Programmable Control Functions

The Allen-Bradley ControlLogix™ system takes a new approach to integrating motion and sequential control. The ControlLogix system performs these functions within a single controller, while other control systems require multiple controllers and programming packages. The ControlLogix system achieves this by embedding motion control functions in RSLogix 5000™ programming software and the Logix5550™ controller. The ControlLogix approach results in faster application development and integration, higher system performance, and greater ease of start-up and maintenance.

Distributed Processing Heightens System Performance and Integration

ControlLogix employs synchronized, distributed processing to provide a motion solution offering heightened performance and integration. The Logix5550 controller executes ladder-based motion commands and a motion trajectory planner while the 2-Axis Servo module executes a fine planner and closes a position and velocity loop. Benefits of the approach include:

- common execution of motion and sequential commands on the Logix5550 controller for complete synchronization of sequential and motion control
- fast 200-microsecond fine planner, position loop and velocity loop closure for all axes in a ControlLogix chassis to provide precise motor position and velocity control
- modular processing, including the ability to add Logix5550 controllers to the ControlLogix chassis, for additional processing power as needed
- control of up to 32 axes from a single Logix5550 controller application program

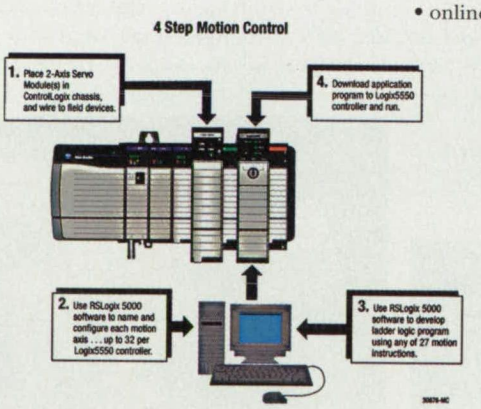
Rockwell Automation
Response Center, Dept. 0429
10701 Hampshire Ave. South
Bloomington, MN 55438
Tel: 800-223-5354, ext. 0429
Fax: 800-500-0329

Within the ControlLogix system (background), the 2-Axis Servo module (foreground) provides the drive connectivity and control.

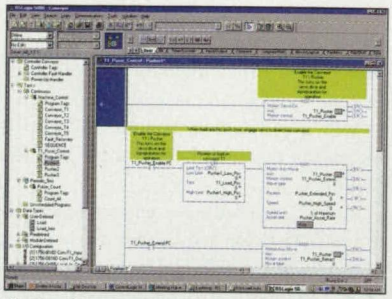
An integral part of the Logix5550 controller's instruction set are 27 motion commands, including:

- homing
- jogging
- point-to-point positioning
- gearing
- high-speed position registration
- auto-tuning

The 2-Axis Servo module (1756-M02AE) provides the drive connectivity and control. Standard features include:



ControlLogix provides an integrated programming environment for both motion and sequential control that enables faster development of application programs, higher performance, more complete integration, and improved ease of maintenance.



The Logix5550 controller offers highly integrated motion control that requires just one software tool to learn and one program to maintain for both motion and sequential control.

- 2 channels of 4MHz quadrature encoder input and 16-bit analog outputs
- 2 high-speed 1-microsecond registration position latches
- 200 microsecond fine planner, position loop, and velocity loop closure

RSLogix 5000 programming software is the only programming software needed to fully configure and program an integrated Logix5550 motion solution. Software motion features automate what was often a manual motion control development process. Features include:

- wizard-driven axis configuration and commissioning
- drive hookup diagnostics and autotuning
- ladder-based application programming, including 27 motion control commands
- online editing and monitoring

Maintain Your Motion Application Easily

Having a single, integrated package makes maintenance and troubleshooting easier because the same programming environment is used for both motion and sequential control during development and operation of the system.

Circle No. 770

GaGe

Gage Applied Sciences Inc.

Manufacturer of the World's Fastest Data Acquisition and Instrumentation Products

Gage Applied Sciences was founded in 1987 with a mandate of designing, manufacturing and marketing high-quality, high-speed data acquisition and instrumentation products based on the IBM PC platform.

Today, Gage is the recognized leader in the ultra-fast data acquisition market with its family of multi-MegaHertz A/D cards, D/A and ARB cards, and Digital Input cards for the PCI and ISA Bus. Whether your need is for 8 bit, 12 bit or 16-bit resolution, Gage offers the fastest cards available worldwide.

World's Fastest A/D Cards on PCI Bus

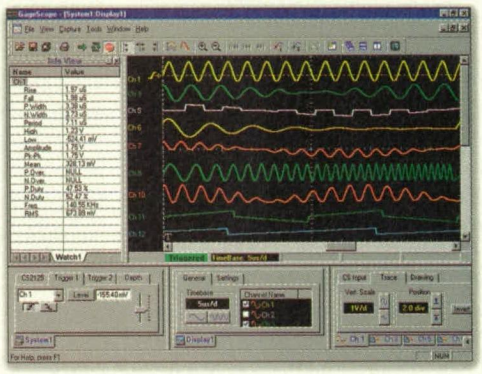
Gage manufactures the world's fastest PCI Bus A/D card, CompuScope 8500, with sampling rates of 500 MS/s and very deep memory buffers of up to 16 million samples. Data can also be transferred across the PCI bus to PC memory at rates up to 100 MB/s.

Other products include the CompuScope 12100, a single slot PCI bus A/D card sampling at up to 100 MS/s with 12 bit resolution, the CompuScope 1016, a 16 bit A/D card with sampling rates up to 10 MS/s, and many other models which provide excellent performance at a reasonable price.

One of the most unique features of the CompuScope product line is the very deep memory buffers it offers: up to 16 million samples. This allows the user to digitize an analog signal at very high speeds for a very long period of time. Digitized data can also be streamed across the PCI bus providing hundreds of Megabytes of storage.

GageScope for Windows: World's Most Powerful Oscilloscope Software

A solutions-oriented software package allowing you to control all parameters of CompuScope cards with a click of the mouse — plus view and analyze the captured signals. Optional Waveform Parameters allow for the automatic measurement and display of Rise Time, Fall Time, Pulse Width, Frequency, Amplitude, and many others. With up to 1 million point FFTs possible, the GageScope for Windows FFT Plug-In is one of the most powerful FFT packages in the world.



LapScope: The Intelligent Field Instrument

LapScope is a powerful, Plug-n-Play instrument peripheral to a laptop computer that enables users to combine the computing, displaying and communicating power of their existing laptop computers with the high performance signal acquisition and digital oscilloscope (DSO) capabilities of Gage products.

Multi-Channel ARB Card

Gage's high speed Arbitrary Waveform Generator, CompuGen 1100, can provide up to 8 simultaneous ARB channels with 80 MHz Conversion rate with up to 16 Million point waveform memory. CompuGen 1100 provides simultaneous analog outputs with independent phase control.

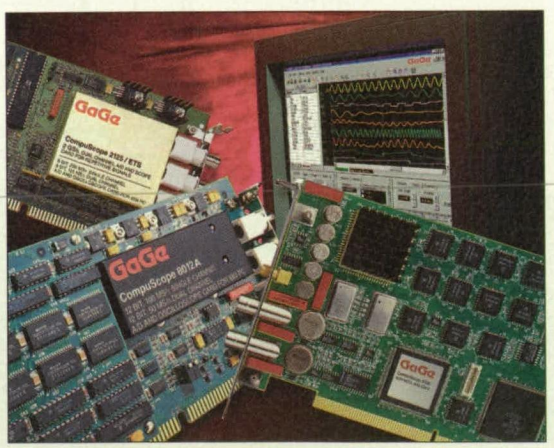
Software Support

Gage offers a wide variety of software drivers available for custom programming in DOS, Windows 95 and Windows NT. Gage also supports third party packages such as MATLAB and LabVIEW.

Applications

CompuScope cards have been used in many applications such as non-destructive testing, Medical Ultrasound, LIDAR, Radar, Laser Doppler Anemometry, Telephony, Communications, Disk Drive Testing, Manufacturing Test, and many others.

The list keeps on expanding every day as scientists around the world find more ways of utilizing computers to solve problems by analyzing digitized data.



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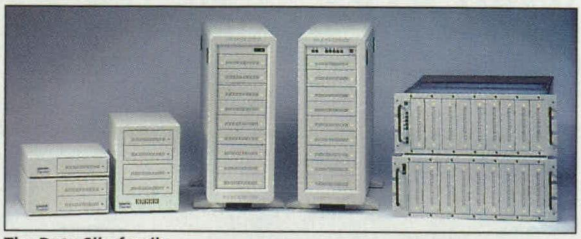
Circle No. 776

Kingston® TECHNOLOGY

Kingston Flexible Storage

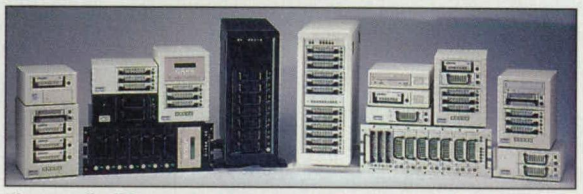
Kingston Technology is a nationally recognized leading manufacturer of storage enclosures. The Storage Products Division of Kingston was established in 1989, offering storage upgrades to its customers emphasizing the same philosophy that made Kingston's memory division so successful. Kingston Storage installations include Fortune 1000 companies, educational institutions, and countless government agencies worldwide.

Developing quality products is a Kingston trademark. Kingston storage products are sold worldwide through a select group of strategic partners including national and regional distributors.



The Data Silo family

The Data Express Group



Kingston flexible storage products

Mix & Match For Flexible Storage Solutions

Kingston's storage products provide solutions specifically designed to reliably support increased storage capacity and system flexibility. Use the Kingston rugged Data Silo expansion chassis, available with up to 9 bays, to accommodate fixed storage needs. Utilize the reliable Data Express removable drive trays for system internal removable storage. Combine Kingston's Data Silo and Data Express units for a variety of custom external removable solutions.

More About Our Products

- **Data Silo DS500 Chassis (9-bay Rackmount or Tower)** Our Data Silo DS500 is a steel rackmount or tower, RAID or JBOD (Just a Bunch of Disks) external expansion chassis designed to reliably house any combination of up to 9 half-height (or 4 full-height and 1 half-height) devices. Used in conjunction with our Data Express removable device enclosures, the DS500 can house up to 12 removable devices.

The Kingston DS500 can support up to 4 host systems. This enclosure comes standard with a power-on LED indicator, 2 300-watt, highly-rated, load-sharing, hot-swappable power supply(ies), and 4 fans, 2 quick-release and hot-swappable. The DS500's front operator display panel provides a visual and audible warning alarm system that reports dangerous operating conditions.

Each DS500 unit is designed to support a variety of storage applications, from daisy chain configurations to high-performance RAID solutions. The DS500 is compatible with all popular platforms.

- **Data Silo DS100 Chassis (1, 2 & 4-bay)** The Kingston DS100 family of expansion chassis can house up to (4) 3.5" or 5.25" half-height, or (2) 5.25" full-height SCSI peripherals. Each DS100 is constructed of rugged steel and is designed to easily withstand the high temperatures generated by today's high-performance devices. These chassis are equipped with internal wiring, blank filler panel(s), and highly-rated, auto-ranging, enhanced power supply(ies) and fan(s).

Various available versions of the Data Silo provide flexible options for storage expansion, making our Data Silo enclosures ideal for desktop, JBOD and RAID, single and dual port disk arrays. Combine our Data Silo DS100 chassis with our Data Express removable subsystem units and enjoy the convenience of up to 6 removable devices in a small footprint, desktop storage enclosure.

- **Data Express (Removable Device Enclosure)** The Kingston Data Express line of removable device enclosures can house any 3.5" drives or 3.5" front-load type devices. Data Express subsystems are mountable into any internal or external 5.25" half- or full-height peripheral expansion bay (model dependent).

Kingston Data Express units are solidly constructed and employ highly reliable mating connectors that are rated as high as 25,000 insertion cycles for most models. An ID select indicator, device carrier key lock, device activity indicator light, and antistatic insertion guide rails are standard features on most models. Hot-swap capability and solenoid device locks are available options on some models.

Our Data Express modular subsystems are ideal for applications that require cold, warm, or hot swapping of devices. In addition, the Data Express is perfect for data transfer or transportation, data security, archiving large files, JBOD, and RAID applications. "Mix and match" our Data Silo standalone expansion chassis with the Data Express for a custom, external removable solution.

Warranty & Testing Information

All Kingston Storage Products carry a 7-year warranty, the longest in our industry, and a 30-day, no-questions-asked, money-back guarantee.

Every Kingston storage product is 100% tested and burned-in for 24 hours prior to shipment. All of our products are UL, CSA, and TuV approved and are designed to meet FCC class B and CE specifications.

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Circle No. 781

American Variseal

Spring-Energized PTFE Seals for Extreme Operating Conditions

The drive to improve the performance of fluid-power systems is causing design engineers to search for better seal alternatives. Until recently, elastomeric materials have generally kept pace with rising performance requirements. During the last few years, higher operating pressures, temperatures, speeds, and chemically aggressive fluids have forced designers to look beyond traditional seal designs. The seal alternatives they seek are spring-energized seals made from PTFE (polytetrafluoroethylene).

Spring-energized PTFE seals combine the advantages of PTFE compounds with the resilience of springs. American Variseal's Turcon® compound — a blend of PTFE resins and fillers — provides a chemically inert seal with low friction, excellent wear resistance, and no stick-slip.

Three key factors in matching the seal to an application are Seal Materials, Cross-Section, and Spring Designs. Following is a closer look at each of these factors.

Seal Materials

PTFE compounds are formulated to optimize material properties. Adding fillers like carbon, glass, graphite, or molybdenum disulfide (MoS_2) improves both wear and extrusion resistance, which is good for high-pressure applications. Nonabrasive polymeric fillers are used for applications where the seal contacts an exceptionally soft mating surface.

Unfilled virgin PTFE is the first choice for applications requiring FDA-compliant seals. Frequently, UHMWPE (ultra-high-molecular-weight polyethylene) is used for temperatures below 200°F.

For applications with extremely abrasive media, cryogenic temperatures, and intense radiation, other materials are available.

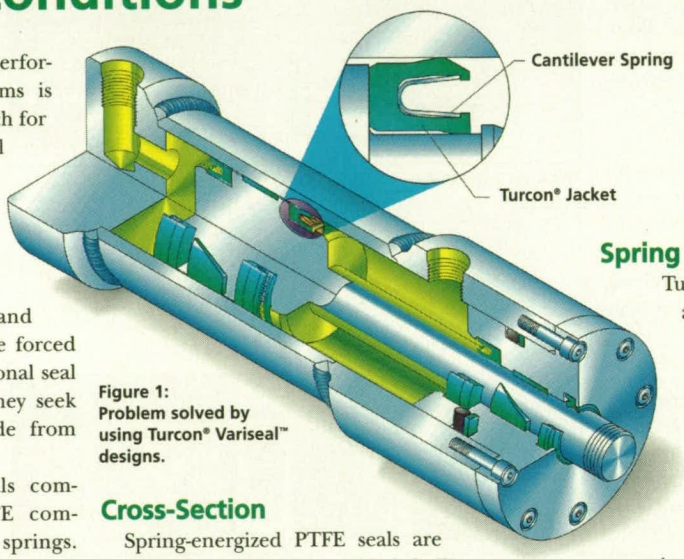

Figure 1: Problem solved by using Turcon® Variseal™ designs.

Cross-Section

Spring-energized PTFE seals are machined, not injection molded, facilitating customization to meet specific application requirements.

Standard Variseal™ profiles are rated for pressures up to 3,000 psi. Variseal™ profiles with an extended heel or back-up ring are rated for pressures above 10,000 psi and 100,000 psi, respectively. As pressures rise, the radial gap between the seal gland and mating hardware must also be reduced to minimize extrusion.

The seal lip can be modified to meet specific requirements. The standard lip design is chamfered, which aids in installation. A sharp-edged wiper lip design is used for applications requiring a more positive scraping action, or as a seal-retention aid within a stepped gland.

Spring Designs

Turcon® Variseal™ seals are energized by springs made from stainless steel and other highly corrosion-resistant metal alloys. American Variseal offers three spring types to meet specific friction requirements.

The Helical spring provides the highest unit load across the smallest deflection range and is generally reserved for static and slow reciprocating applications.

The V-spring is primarily used for reciprocating motion but can also be used for moderate-speed rotary applications. This spring provides load near the edge of the lip, creating an excellent wiper.

The Slantcoil® spring is an innovative patented design that utilizes slanted coils to load the seal radially. This spring offers the greatest amount of friction control and maintains a nearly constant load over the life of the seal.

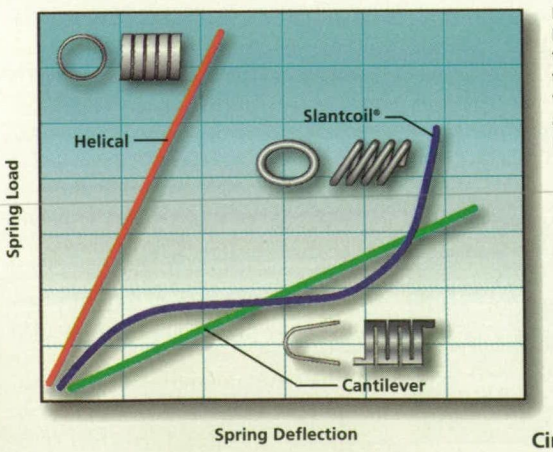

Figure 2: Load curves for three spring types designed to meet any application requirement.

American Variseal Corp.
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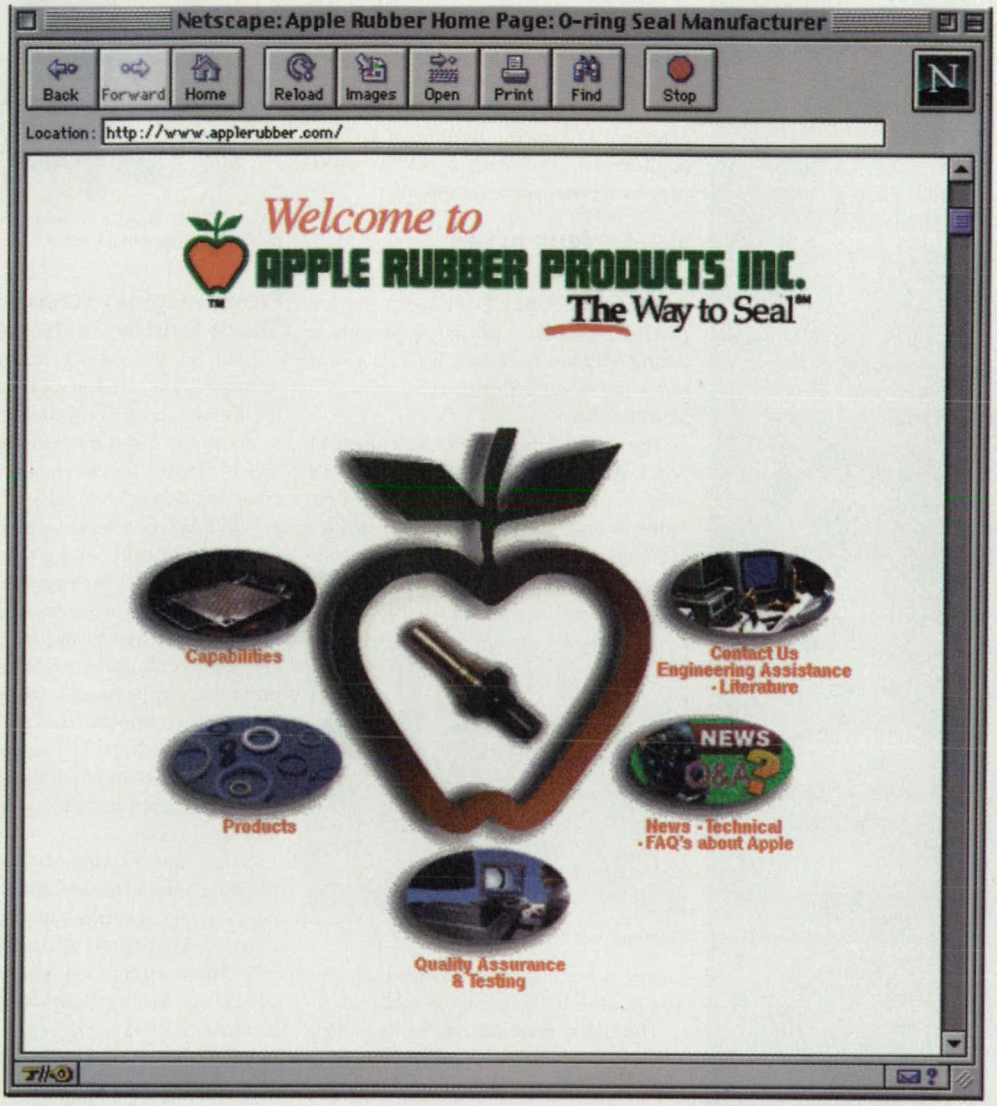
www.variseal.com

Circle No. 786

APPLE RUBBER PRODUCTS INC.



www.applerubber.com

Apple Rubber Products' Web Site offers complete details on the company's extensive range of products and capabilities, and provides one of the industry's most comprehensive resources for information on sealing technology. Visitors can access a unique Engineering Assistance Request page, which allows them to electronically interface with the company's engineering department to request design assistance.

Visitors can also learn about Apple Rubber's complete product line including the industry's broadest inventory of O-rings; MicrOring™ microminiature seals; MacrOring™ oversized seals and O-rings; custom-molded shapes; composite seals such as rubber bonded to metal, plastic, Teflon™ or filter material; and Liquid Silicone Rubber seals produced by Liquid Injection Molding.

Visit www.applerubber.com

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Circle No. 750

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Value-Added Fastener Products

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Aerospace Nylok
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Hawthorne, NJ 07507
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Fax: 973-427-4723

The Nylok Fastener Corporation originated the TRUE BLUE® nylon locking element for internally and externally threaded self-locking fasteners over 50 years ago, and is a leading supplier of value-added fastener products with an extensive, increasing portfolio of patents, applications, and trademarks for products, processes, and equipment.

Nylok® TRUE BLUE® Self-Locking Fasteners

Nylok TRUE BLUE self-locking nylon patches, pellets, and strips provide a strong, vibration-resistant hold in a wide range of manufacturing applications in all industries.

The self-locking process developed by Nylok sprays a nylon patch, or embeds a strip or pellet, onto the threads of a fastener or nut. When the mating threads are engaged, the nylon material is compressed and establishes a counterforce. As the nylon tries to regain its original shape, a strong metal-to-metal contact and positive locking force is established.

Coatings, locking, and sealing products

The nylon material retains its locking properties at high temperatures and is unaffected by gasoline, oil, or many other natural elements. It also provides excellent sealing properties because the locking device acts as a dam by preventing fluid leakage around the threads. Nylok TRUE BLUE self-locking fasteners can be reused a number of times wtihout losing effectiveness.

Coatings, Locking and Sealing Products

Nylok also offers an extensive variety of coatings and chemical adhesives, including NYTEMP®, a locking element that resists temperatures up to 450°F; PRECOTE® chemical adhesives; NYCOTE®, a coating that masks threads against weld spatter and buildup from electrodeposited primer and paint; and NYSEAL®, a self-sealing coating which creates a gasket-type seal.

NYLOK® TRUE BLUE® self-locking nylon patches, strips, and pellets

From Eyeglass Screws to Space Shuttle Fasteners

From its five manufacturing facilities strategically located across North America, Nylok can process fasteners of virtually any size — from tiny eyeglass screws to Space Shuttle fasteners and extra-large construction anchors. All four U.S. plants are NVLAP accredited to meet all major prevailing torque and torque tension standards. Nylok also maintains a state-of-the-art quality assurance laboratory, which utilizes Statistical Process Control, and a research and development department that can accommodate special prototypes and provide free samples. The company distributes its products through an engineer-oriented sales staff and a network of 13 manufacturer sales representatives.

Nylok has expanded into a multinational organization with worldwide sales through a network of 20 licensees in Europe, Asia, South America, Australia, and Africa authorized to produce and market the Nylok self-locking process and its other products.

Whether they make rifles or rivet guns, space shuttles or rockets, luxury sports coupes or diesel trucks, jet-skis or high-performance boat engine mounts, all manufacturers are faced with the task of fastening components in a reliable and cost-effective manner.

Eliminates Need for Additional Locking Parts

Nylok's value-added fastener products and processes improve efficiency in every manufacturing industry because they eliminate the need for additional locking parts (such as washers, springs, or lockwires), require no special pre-assembly machining, need no in-plant application of adhesives or other coatings, and lower manufacturing costs through less labor time spent on fastening.

Circle No. 758

Self-Locking Fasteners: Reliable, Cost-Efficient Partner in Aerospace/Aviation Industries

By Ernest O. Thomsen, Technical Sales, Nylok Fastener Corporation

The aerospace and defense industries remain a viable market for self-locking fasteners. There are still many military and defense contracts to be won, many plans to update the commercial air fleet, and many comprehensive programs to explore space.

Because of their reliability and cost-effectiveness, prevailing torque self-locking fasteners have been crucial to the aerospace, military, and aviation marketplaces for over 40 years — and will continue to be so. Labor-intensive fastening of components represents between 20-40 percent of manufacturing costs, and self-locking fasteners reduce this cost by eliminating the need for washers, springs, lockwires, and additional locking parts.

Prevailing torque self-locking fasteners are used on virtually every major defensive and offensive weapon system produced by the U.S. and our NATO allies. From high-tech jet fighters and state-of-the-art spacecraft, to the commercial airplanes we all fly on, prevailing torque self-locking fasteners have a wide range of important aerospace and aviation applications.

Defense Systems

The Sidewinder missile is a perfect example. Because of the vibration and wind pressure produced at high speeds on the air-to-air Sidewinder, the wing assemblies are secured with self-locking fasteners. The wing assembly on this highly effective weapon is critical to the missile's stability and guidance.

In the mid-1980s, Nylok Fastener Corp. provided self-locking devices on five types of fasteners for the Sidewinder: the slotted, flat-point 7/8" 1/4-28 UNF-2B fasteners that position the wing assembly; a 1-3/4" long cap screw and 1/4-28 UNF-2B fastener to lock the assembly; a 10-32 UNF-2B flat-head machine screw to hold the hinge of the rolleron assembly to the wing assembly; two 6-32 flat-head machine screws that lock the roller to the damper; and six 8-32 flat-head machine screws to keep the rolleron case intact.

Other recent defense applications include: self-locking fasteners specified to attach the outside skin to the main frame of the Tow Missile; the Patriot Missile that came to prominence in Desert Storm features self-locking fasteners on all areas of the system; and the guidance systems on the Minuteman Missile have special platinum screws with self-locking elements to balance the gyro mechanism.

Fast-curing PRECOTE® screw locking and thread sealing chemical adhesive system utilizes a patented process that microencapsulates both the epoxy resin and hardener separately.

Aircraft and Space

One of the primary concerns in the design of a military aircraft is pilot safety. Consequently, self-locking screws are used extensively on crew ejection seats and modules for their reliable performance. Other military aircraft applications for self-locking fasteners include use in the hydraulic systems, securing cargo doors, and cargo restraints.

In commercial aircraft, self-locking fasteners are used as a redundant locking system to attach turbine blades in jet engines. There are also many applications inside the aircraft, from cockpit control knobs and galley doors, to overhead luggage compartments, to cabin partitions, passenger seats, and seat-back trays.

NYTEMP® processed fasteners, made of high temperature-resistant polymer, feature a locking element applied as an orange-colored patch to internally or externally threaded parts.

As we approach the 21st century, self-locking fasteners will continue to be an integral part of our space exploration program. In some cases, they are used independently, but in critical applications, they are used as a redundant locking system with lockwires or other mechanical means.

The craft in the Space Shuttle program use self-locking fasteners to secure the cargo platform in the bay area, and its booster rockets rely on the fasteners for flawless performance. In July of this year, self-locking fasteners returned to Mars, having been part of the original Mars Lander program years ago.

Design Considerations

In the self-locking process, which was developed by Nylok Fastener Corp., a nylon patch is sprayed onto the threads of a fastener or nut (or a pellet or strip is inserted). When the mating threads are engaged, the resilient nylon material is compressed and establishes a counter-force. As the nylon tries to regain its original shape, a strong metal-to-metal contact and positive locking force is established.

The nylon material retains its locking properties at high temperatures and is unaffected by gasoline, oil, or many other natural elements. It provides excellent sealing properties because the locking device acts as a dam by preventing fluid leakage around the threads. Self-locking fasteners can be reused without any loss of effectiveness, and certain self-locking elements, such as the orange polymer NYTEMP® patch, provide resistance of temperatures to 450°F.

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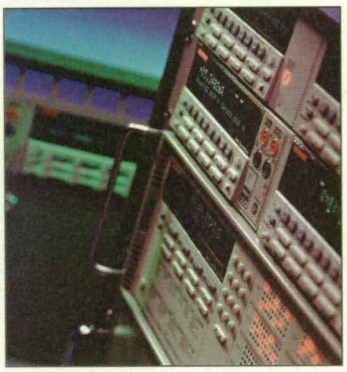
Circle No. 758

KEITHLEY

A World of Measurement Solutions

Keithley Instruments, Inc. develops highly accurate instruments and data acquisition products that measure low levels of voltage, resistance, current, capacitance, and charge, along with complete system solutions for high-volume production and assembly testing. As a world leader in precision electrical measurement solutions, the company specializes in designing equipment for research, design engineering, and production test applications in a wide range of electronics industries. Keithley's test and measurement solutions can be found in university and government laboratories, industrial research and development centers, and quality control and product test areas worldwide.



Since the company was founded in 1946, the test and measurement industry has recognized the innovation behind Keithley products with dozens of awards. Long acknowledged as a pioneer in the development of measurement tools for ultra-low level phenomena, today's Keithley has expanded its focus to develop new solutions for several growing markets.

Telecommunications/Wireless

Keithley offers a broad line of fully-integrated products for testing portable telecommunications devices such as cellular phones, pagers, mobile radio base stations, and digital switch systems that are used in product design, production, and QA/QC labs.

Semiconductor

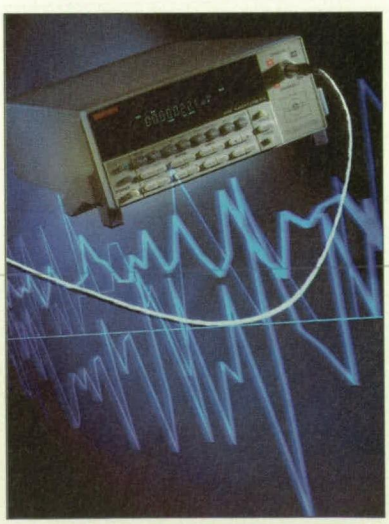
The company's semiconductor industry products include instruments and systems widely used in design and development, as well as systems for wafer process monitoring and parametric testing. These solutions include three Automated Parametric Test systems and I-V/C-V test instruments and systems. The S600, Keithley's latest parametric test solution, has recently been honored with awards recognizing it as one of the best products of the year.

Electronic Components

Keithley's growing line of high-throughput solutions for component testing encompasses the entire spectrum of control, connect, and source-measure instrumentation. Keithley's measurement products are widely used for production testing of diodes, transistors, resistors, capacitors, sensors, and other electronic components.

Recently, Keithley test and measurement innovations have included a growing line of PCI-based data acquisition and digital input/output boards, high-speed power supplies optimized for testing battery-operated wireless devices, and several additions to its already broad line of switch cards, many optimized for testing telecommunications hardware.

Keithley's latest sensitive instrument, the Model 6514 Electrometer, is designed for applications that demand both high throughput and femptoamp resolution. Though priced similarly to a high-precision digital multimeter (DMM), the 6514 provides better data at higher speeds with a much higher input resistance and lower voltage burden than DMMs. Perfect for production testing as well as R&D applications, the Model 6514 features measurement speeds up to 1200 readings/second, digital I/O lines, and a component handler interface for fast testing, easy setup, and simple system integration, and line cycle integration and a 60dB normal mode rejection ratio to minimize noise errors.



Another new sensitive instrument, the Model 2182 Nanovoltmeter, has lower noise than either earlier type of nanovoltmeters or sensitive DMMs. Its design has been optimized to make low noise measurements in just a few seconds and to measure low-resistance materials or devices by using the reversed-current method. The result is a nanovoltmeter that provides significantly lower noise performance for real-world measurements made at rates faster than the thermal time constant of the sample. This makes the Model 2182 a much better choice than DMMs or earlier nanovoltmeters for research, metrology, and sophisticated low-voltage testing applications. It also offers the greatest measurement value of any nanovoltmeter available.

With more than 550 employees, subsidiaries in Belgium, China, France, Germany, Great Britain, India, Italy, the Netherlands, Switzerland, and Taiwan, and sales representatives in more than 40 countries, Keithley offers the world "A World of Measurement Solutions."

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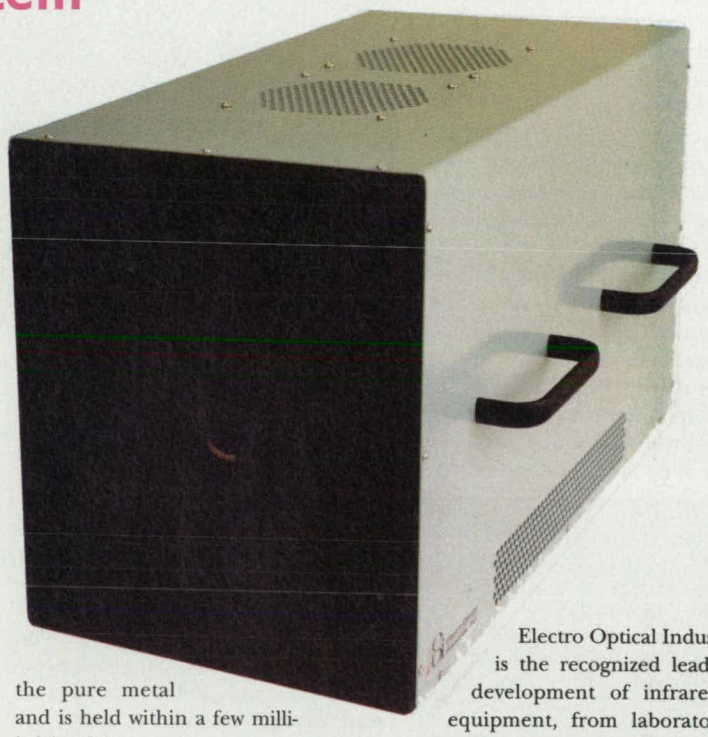
Circle No. 775

Electro Optical Industries, Inc.

EOI Introduces the Multi-Point Freezing Point Blackbody System



Electro Optical Industries, Inc. (EOI) announces the introduction of the Multi-Point Primary Standard Blackbody (MPPSB) system used to precisely calibrate radiometers, pyrometers, and other non-contact thermometers and thermal imagers. The MPPSB system provides blackbody radiation at the International Temperature Scale (ITS-90) freeze point temperature of indium, tin, zinc, aluminum, silver, gold, and copper.

A unique and cost-effective feature is the use of interchangeable melt material crucibles. This provides the option of multiple freezing point calibrations in a single system. Each crucible contains the high purity metal and a highly emissive (.9997) reverse cone blackbody cavity. The cavity is completely surrounded by the pure metal and is held within a few millikelvin of the metal temperature as it transitions from liquid to solid. An equilibrium is achieved during this transitional phase and the temperature remains stable at the precise value defined by ITS-90. The MPPSB system is unique among commercially available systems, providing 30 to 60 minutes for calibration.

Additionally, the MPPSB system can be used as a variable temperature blackbody, operating at any temperature below the freeze point of the selected crucible. In the variable temperature mode, the system performs as a standard laboratory blackbody similar to the EOI Secondary Standard Blackbody Series.

Electro Optical Industries, Inc. is the recognized leader in the development of infrared testing equipment, from laboratory standalone instruments to fully integrated test stations. EOI has provided both military and commercial clients with state-of-the-art equipment for over 34 years. Their modern design and manufacturing facilities are located in Santa Barbara, CA, with total employment of over 70. Standard products are supported and supplemented by a responsive and knowledgeable management, engineering, and manufacturing team. EOI's team also designs and produces modified or custom instrumentation with exclusive performance. EOI has designed, built, calibrated, and delivered over one thousand different models of blackbodies and numerous infrared test and simulation systems.

Electro Optical Industries, Inc.
859 Ward Drive
Santa Barbara, CA 93111
Tel: 805-964-6701
Fax: 805-967-8590
e-mail: eoi@sonatech.com

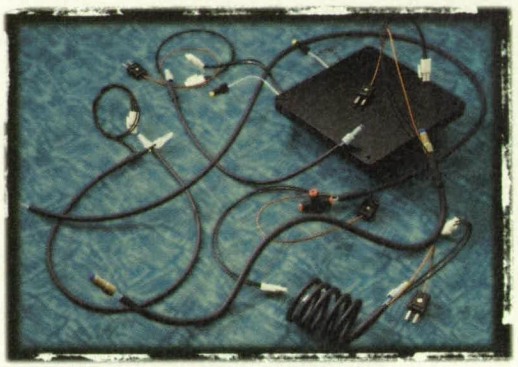
Circle No. 774

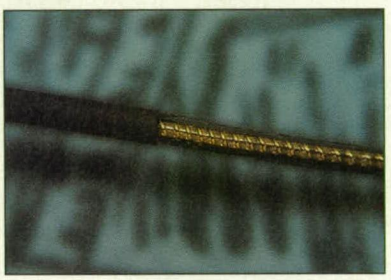
WATLOW

Watlow Develops Miniature Heated Polymer Tubing Assemblies

Moving fluids can now be heated to 212°F (100°C) inside polymer tubing as small as 1⁄32 inch in diameter. Preheated fluid temperatures can also be maintained during transfer from a reservoir to a point-of-use with Watlow's new heated tubing assemblies. In some applications the tubing can actually serve as the reservoir for limited volumes of heated fluid.

Watlow's innovative design places the heating element directly in contact with the perimeter of the tubing to produce efficient, responsive heating and temperature control of the tube contents. This element is evenly wound to ensure close contact for uniform heating along a portion or the entire length of the line. The heated tubing can remain flexible, be formed, or encapsulated, to meet specific needs of the application.





Applications

- Aerospace
- Analytical equipment
- Life sciences (medical)
- Military
- Office equipment
- Semiconductor processing

Two versions are currently available primarily for OEM applications. The FREEFLEX version has a flexible and durable jacket over the wound element that allows tubing to flex and move in a dynamic system to deliver fluids to multiple locations. In stationary applications, the FREEFLEX heated tubing can be conveniently formed and routed around other system components. The molded, or encapsulated, version encases the preformed heated tubing in a thermally conductive or insulating resin to form a rigid assembly complete with optional mounting features. The tubing typically is preformed to a flat or cylindrical shape. These designs can be more efficient than solutions employing heaters cemented to the surface of a "tubing-only" mold or tubing clamped between heated metal plates with only an angled thermal contact to the tubing.

Features	Benefits
• Element directly contacts tubing	• Fast, efficient, more responsive heating
• FREEFLEX design	• Leaves tubing free to flex, coil or bend around other system components
• Molded design	• Compact heating assembly for easy installation
• Integral sensors	• Close control of heater and fluid temperatures

Both superior constructions employ the same efficient heating element design with the ability to incorporate optional thermocouple or thermistor temperature sensors into the thermal package. Users can select leads to exit one or both ends of the assembly. Typical standard tubing comes in 1/32, 1/15, or 1/8 inch inner diameters (I.D.), although other sizes are available if the application requires.

"Watlow's FREEFLEX and molded heated tubing assemblies are very versatile heating solutions," explains Ron Shadwick, advanced product manager. "Because they can be designed in the exact shape and size the customer requires, applications are virtually limitless."

Contact Watlow if there is a specific OEM application that benefits from this new technology.

Watlow
12001 Lackland Road
St. Louis, MO 63146
Tel: 314-878-4600 or
800-WATLOW-2
Fax: 314-878-2369
www.watlow.com

Circle No. 769

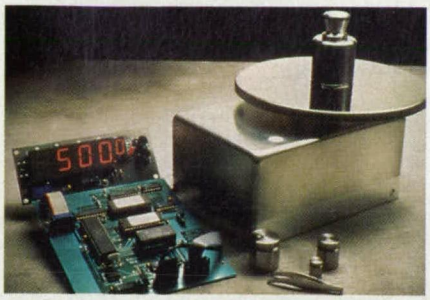
Sensors

New on the MARKET

Flat-Panel Monitor

Silicon Graphics, Mountain View, CA, offers the Silicon Graphics® 1600SW™ digital flat-panel monitor, which features a 17.3", 1600 × 1024 pixel SuperWide™ format screen for use with current Silicon Graphics O2™ workstations, as well as future workstation products for Windows NT. The SuperWide format is similar to High-Definition Television (HDTV) with a 16:10 aspect ratio. It also allows users to display two entire pages of information simultaneously. It consumes less than 30 watts and weighs 16 pounds with the desktop stand. Other features include 110 dpi at a 0.23 mm dot pitch, 24-bit true color support, and high levels of color saturation, brightness, and contrast. A new technology enables the user to adjust the color temperature independently from gray-scale. All key characteristics of the display are adjustable from point-and-click panels in the user interface. The tilt of the display can be adjusted within a 20-degree range, and the monitor can be raised or lowered 3.5" via a control arm. A Digital Flat Panel Solution Pack, comprised of the monitor and 32-MB Revolution IV-FP™ graphics card from Number Nine Visual Technology is available for Windows 95/98/NT. **Circle No. 704**

High-Precision Load Cell



The Mass Monitor moment-insensitive load cell from Setra Systems, Boxborough, MA, features high resolution, a patented variable capacitance ceramic sensor, weighing platform, custom signal conditioning circuitry, and optional electronic display board. The load cell module is available in any weighing capacity from 200 grams to 50 kilograms, and is accurate to 10 ppm. Software enhancements include resolution selection, a choice of display update settings, and expanded calibration options for operating in harsh environments. The load cell can be installed in any scale base or other weight-supporting structure using only three bolts. The electronic circuit also includes a display connector and RS-232 serial data interface for bi-directional communication with the controlling or indicating device. **Circle No. 703**

Integrated Portable Computer

The PXI-1025 MegaPAC integrated portable computer from National Instruments, Austin, TX, is based on CompactPCI and PXI specifications, and features a flat-panel LCD, keyboard, pointing device, and CD-ROM drive. Developed together with Dolch Computer Systems of Fremont, CA, the unit combines the modular architecture of CompactPCI and instrumentation extensions of PXI, with a portable platform. The computer includes a compact 3U size, integrated timing and triggering, AC and DC power options, fold-away keyboard, and seven PXI/CompactPCI extension slots. Designed for field test applications and data acquisition, the system uses an embedded computer module available with Pentium processors running Windows 98/NT software. It features a 4-GB hard drive and floppy drive, optional GPIB port for instrument control, and Eurocard construction. **Circle No. 701**

Epoxy Curing Adhesive

Master Bond, Hackensack, NJ, has introduced the EP33 room-temperature curing adhesive for high-temperature bonding applications. The adhesive system has a service operating temperature range from -60°F to +450°F. It produces high-strength bonds that are resistant to thermal cycling and chemicals, and provides adhesion to metals, glass, ceramics, wood, vulcanized rubber, and most plastics. The hardened adhesive also is an electrical insulator. The adhesive can be applied without sagging or dripping, even on vertical surfaces, and is 100 percent reactive. It is available in ½-pint, pint, quart, gallon, 5-gallon, and drum kits. **Circle No. 705**

New on the MARKET

Smart Image Sensor

DVT Corp., Norcross, GA, offers the Series 600 SmartImage sensor that features 640 x 480 pixel imaging capabilities combined with Ethernet and fieldbus communications. The sensor delivers control data such as quality control inspection results, coordinate information for motion controllers, statistical process control data, and 2D code verification. It has a footprint of 1.6 x 2.2 x 4" and features an embedded PowerPC processor. The camera, image-acquisition electronics, and computer are integrated into a single unit to allow dynamic access of the CCD without image float or flutter. It is shipped with FrameWork 1.4 software, which contains tools such as Precision Measure, Motion Control DataLink, SPC DataLink, and 2D Code Reader. **Circle No. 706**

Analog Oscilloscopes

The LA302 and LA303 analog oscilloscopes from LeCroy Corp., Chestnut Ridge, NY, feature light weight, 100 MHz and 200 MHz bandwidths, and TV triggering with field and line selection. Both models have a display capability that allows easy measurement of relative frequency content of signals mixed together, or the occurrence of low rep-rate events on repetitive signals. Featuring three channels, the LA303 has a bandwidth of 200 MHz; the LA302 operates up to 100 MHz. The third channel on both scopes has a limited set of amplifier sensitivity levels. Both feature a maximum sensitivity of 2 mV/div and maximum sweep speed of 1 ns/div. High-speed auto set-up allows panel settings to be saved and recalled. The scopes feature a fine-adjustment mode that enables slow scrolling of waveforms. **Circle No. 702**

Graphic Dataloggers

The 80610-00 and 80610-10 multi-color graphic dataloggers from Cole-Parmer Instrument, Vernon Hills, IL, are touchscreen displays designed to keep operators informed about facility conditions. They can be used with six or 12 isolated inputs to measure thermocouples, RTD, DC voltage and current, and ohm readings. Users can view data with preconfigured display pages for area, group, group trend/bargraph/numeric, point, and analysis. Trend function, stored in 1-MB video memory, displays current process and historical data to allow comparison data analysis. The 1.4-MB floppy disk drive allows transfer of data to popular spreadsheet software. **Circle No. 700**

Rotary Position Sensor

MPC Products Corp., Skokie, IL, has introduced an RVDT-based DC rotary position sensor that offers the reliability of brushless, no-wear RVDT position sensing for servo valves and other feedback/command applications requiring DC excitation and output signals. The RVDT and HIRF/lightning-protected DC conversion electronics are designed and qualified for exposed on-wing installations, and are housed with a fully environmentally sealed package. Custom input/output voltages, mounting configurations, and extended range (multi-turn) options are available. **Circle No. 707**

New on DISK

Server Software

IOtech, Cleveland, OH, has announced ScanServer™ 32-bit server software that enables the company's measurement and control instruments – ChartScan/1400™, TempScan/1100™, and MultiScan/1200™ – to be used in Supervisory Control and Data Acquisition (SCADA) and Human-Machine Interface (HMI) applications. The software supports SCADA/HMI applications such as Wonderware's InTouch™, National Instruments' Lookout™, and Microsoft's Excel™ and Visual Basic® through OLE for Process Control or most Dynamic Data Exchange formats. It also supports the instruments' temperature and voltage inputs and digital I/O. ScanServer provides hardware configuration services, allowing users to assign channel parameters and poll rates directly from the server application. Programmable channel parameters include turning channel on or off, setting thermocouple type or voltage rates, selecting engineering units, and applying user offset and scale to the channel's value.

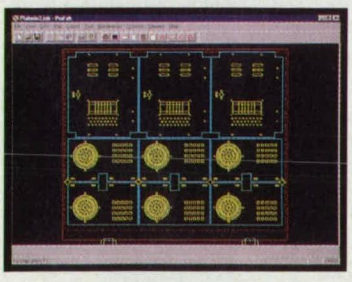
Circle No. 709

Tools for the Product Process

RenderView Software, Woburn, MA, has introduced Engineering Office, a suite of tools for use in the product process that enables engineering and non-engineering personnel to manage corporate and product development data, and share the information with others. The suite consists of personal utilities for managing and communicating concepts, models, data, and changes. It includes an intuitive data management system for creating engineering workbooks and work-in-process folders, and features a visualization capability that allows users to explore, manipulate, and analyze 2D and 3D drawings, models, and assemblies in popular formats. Tools are included for measuring, annotating, and markup; e-mail, fax, web, and scanning also are supported. The software runs on Windows 95/98/NT platforms. **Circle No. 716**

Sheet Metal CAM Software

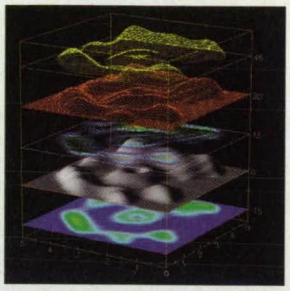
ProFab 3.0® for Windows sheet metal CAM software from Applied Production, Milford, OH, is a 32-bit standalone software designed to automate the task of programming CNC punch presses in applications such as aerospace, automotive, electronic enclosures, machinery, and consumer products. It offers techniques for tool selection and turret assignment, smart machine interfaces for machine code, and optimization routines to increase shop floor productivity. Available for Windows 95/98 and NT operating systems, the program works with part geometry imported from any CAD system with DXF or CADL data translators. The software supports auto-index stations, multi-tool stations, and laser machine tools.



Circle No. 710

CFD & Engineering Visualization

Amtec Engineering, Bellevue, WA, has announced Tecplot version 7.5 computational fluid dynamics (CFD) and engineering visualization software. The new release introduces the Tecplot ADK (Add-on Developer's Kit), which includes an application programming interface and set of software tools that allow users to customize and extend the functionality of the software. The ADK allows users to modify, configure, and augment the capabilities of Tecplot to address specific needs. Developers can create standalone applications that can access all of Tecplot's visualization capabilities. Application providers can use the software as an easy-to-use interactive data visualization environment, and as a development library.



Circle No. 712

Data Visualization

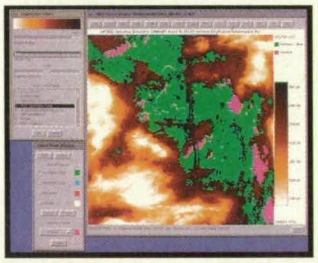
Advanced Visual Systems, Waltham, MA, offers AVS5® visual programming data visualization software for the Linux operating system. The program consists of a suite of data visualization and analysis techniques that incorporates traditional visualization tools such as 2D plots and graphs and image processing, as well as tools such as 3D interac-

New on DISK

tive rendering and volume visualization. It enables users to analyze, manipulate, and display large volumes of complex data, including 2D and 3D images, 3D graphics, and multidimensional numeric data. The software provides support for the Linux operating system distribution available from Red Hat Software using the standard GNU compilers. The Linux operating system allows a PC to function as a UNIX workstation for advanced visualization tasks. **Circle No. 711**

Application Development Software

Research Systems, Boulder, CO, has released IDL® Version 5.2 multi-platform technical visualization and application development software. Features include IDL GUIBuilder™, a drag-and-drop development tool for building customized graphical user interfaces. Its platform-independent code makes interfaces developed with IDL GUIBuilder portable to any computer running IDL 5.2 in Windows, Mac OS, Linux, UNIX, or OpenVMS. The new version also offers IDL Insight™, a prebuilt GUI; support for 64-bit files; and support for several new data formats, including HDF-EOS (Hierarchical Data Format-Earth Observation System) and DICOM (Digital Imaging Communications in Medicine). **Circle No. 714**

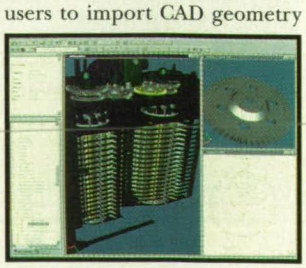


Publish/Subscribe Networking

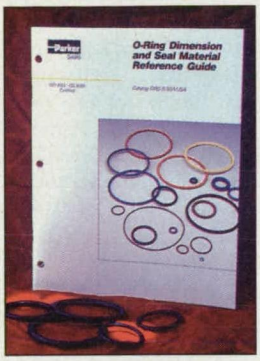
Network Data Delivery Service (NDDS) release 2.0 publish/subscribe networking software from Real-Time Innovations, Sunnyvale, CA, facilitates development and implementation of real-time distributed industrial and research applications, including distributed control, telecommunications, remote sensing, monitoring, and distributed simulation and animation. It is compliant with Wind River Systems' VxWorks, Windows NT/95/98/CE, and UNIX on most platforms. The system is middleware, a layer between the operating system and the application that acts as an electronic messenger, delivering data when and where it is needed. It allows diverse nodes to communicate without network programming, and is effective in systems with repetitive, time-critical data flow. Nodes "publish" the data they know about and "subscribe" to the data they require. The software controls timing, memory allocation, and reliability. **Circle No. 713**

Visualization and Prototyping

VisView 1.1 and VisMockUp 2.1 from Engineering Animation, Ames, IA, are product visualization and digital prototyping software tools that are part of the VisProducts™ suite of design-through-manufacturing solutions. VisView allows users to import CAD geometry and perform measurements on 3D geometry. Information can be viewed throughout an enterprise and with suppliers through database and PDM sharing features. VisMockUp analysis capabilities support characteristics of processes and practices. Assembly sequencing and extraction features allow users to detect possible product fit or form changes. Visual assembly motion, sequence, and playback enable delivery of instructions for assembly and manufacturing personnel. Collision and interference zones can be detected while evaluating those parts where interference is a design requirement. **Circle No. 715**



New LITERATURE



O-Ring Reference Guide

A 44-page catalog of O-rings and seal materials is available from Parker Hannifin, O-Ring Div., Lexington, KY. The reference guide includes basic size, gland design, and material information on O-rings, and features new compounds, specifications, sealing media compatibility tables, and non-standard-sized O-rings. Current ASTM, NAS, AMS, SAE, and military specification listings also are featured. **Circle No. 743**

PC-Based Products

VMIC, Huntsville, AL, has released a catalog of VMEbus, PCI, and CompactPCI hardware, PC-based soft logic systems, and control software. Products include single-board computers, data acquisition and motion control products, serial communication, host computer interfaces and adapters, software products, accessories, and memory products. **Circle No. 742**

Adhesive Tapes

A 12-page brochure from Furon, Hoosick Falls, NY, describes CHR® Pressure Sensitive Adhesive Tapes. Included are CHR adhesive systems, backing substrates, and release liners, with descriptions of the material types available. A reference chart lists product specifications such as nominal thickness, tensile strength, and adhesion strength. Products are categorized according to backing substrate. **Circle No. 744**

Data Acquisition

Datel Systems, Mansfield, MA, offers a 224-page 1999 Data Acquisition Catalog. Included are data acquisition boards, software, and accessories. More than 100 new products are described, such as boards for PCI, ISA, and VME bus. Also featured are specifications, selection charts, block diagrams, and configuration information. **Circle No. 741**

Miniature Clutches

The Polyclutch division of Custom Products Corp., North Haven, CT, offers a 12-page catalog of miniature precision clutches for overload protection or tension control applications. Included are mechanical slip clutches with torque capacities up to 500 inch/pounds; pneumatic slip clutches, which can be adjusted for torque during operation; jaw clutches; one-way clutches; and custom modified clutches for robotics, medical devices, and pacakging machines. **Circle No. 738**

CFD Software

Innovative Research, Minnaepolis, MN, offers a 16-page brochure describing software and consulting services for fluid flow, heat transfer, and related processes. Products include COMPACT, a flexible computational fluid dynamics (CFD) software, and microGRAPHICS™, a PC-based graphics package for fluid flow and heat transfer. Consulting services include constructing or modifying computer codes; developing numerical algorithms, engineering suggestions, and analysis. **Circle No. 736**

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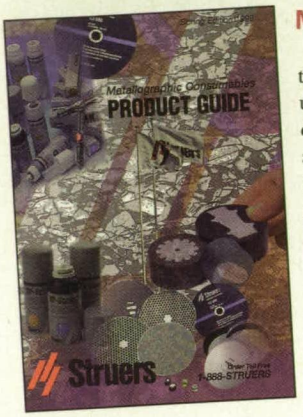
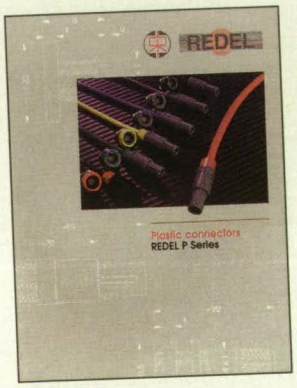


Metallographic Products

Struers, Westlake, OH, has released the Metallographic Consumables Product Guide, a 30-page brochure that describes consumables for use in metallographic specimen preparation. Sections cover cutting and sectioning, mounting and embedding, grinding and polishing, as well as products for hardness testing, nondestructive testing, and electrolytic polishing. **Circle No. 739**

Cam Follower Bearings

A catalog describes TRAKROL® cam follower bearings from McGill, Emerson Power Transmission, Maysville, KY. The bearings have a corrosion-resistant black oxide finish on all external surfaces. In addition to the PCF Series plain, outer-diameter TRAKROL line, the VCF, V-Groove, FCF series, and flange bearings also are available. **Circle No. 740**

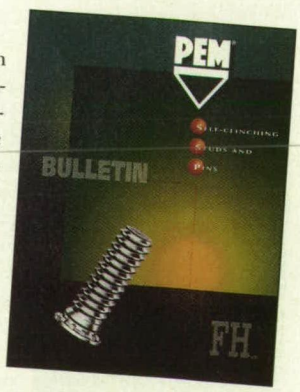


Plastic Connectors

A 12-page brochure from LEMO USA, Santa Rosa, CA, describes the REDEL P Series of plastic connectors, which feature a self-latching system designed so that only a deliberate tug on the plug's outer shell will release the connection. Materials include polysulfone and Polyethermide ULTEM®. Contacts are gold-plated over copper and nickel, and connectors are color-coded. **Circle No. 735**

Self-Clinching Studs & Pins

An 18-page brochure from Penn Engineering & Manufacturing, Danboro, PA, describes PEM® self-clinching studs and pins, including Type FHL™ studs, which are designed to install closer to the edge of a sheet without causing the edge to bulge. The brochure also includes a self-clinching stud selector guide for assistance in selecting fasteners for specific applications. **Circle No. 737**



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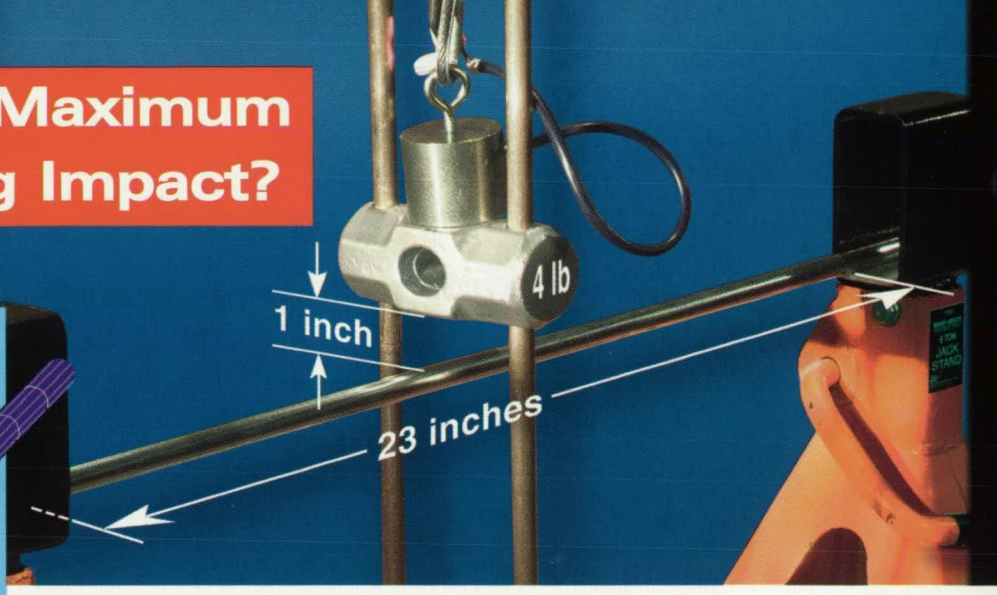
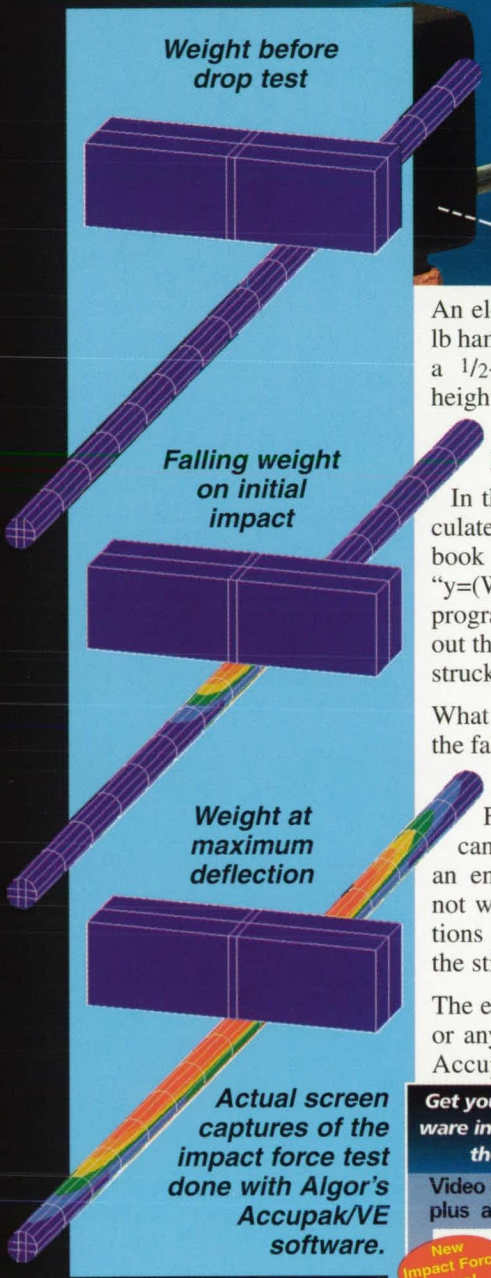
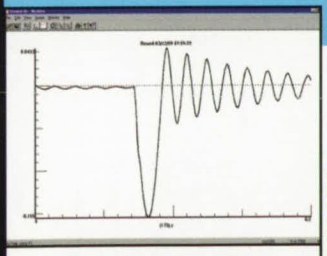
What is the Maximum Force During Impact?





Actual screen captures of the impact force test done with Algor's Accupak/VE software.



Monitor program showing bar deflection vs. time.

An electromagnet suddenly releases a 4-lb hammer head weight which drops onto a 1/2-inch diameter steel bar from a height of 1 inch as shown above. The bar is 23 inches long between the supports.

In the past engineers would try to calculate the maximum stress using handbook calculations such as "s=Mc/I" and "y=(WL3)/(48EI)" or a linear static FEA program — but they would have to figure out the force applied to the bar when it is struck by the falling weight.

What force would you think is caused by the falling weight? (The answer is upside down at the bottom of this page.)

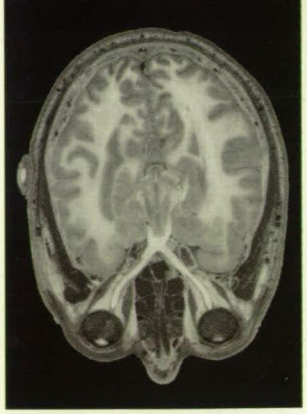
For this simple situation, the force can be approximated by working out an energy balance. This approach will not work, however, for real-world situations due to the difficulty in calculating the stiffness.

The easy way to predict the result of this or any impact problem is to use Algor's Accupak/VE Mechanical Event Simulation software for Virtual Prototyping. Model the bar and hammer head weight with Superdraw III or your CAD system. Apply the dimensions and material properties in Accupak/VE and it will automatically run the virtual experiment and generate a replay showing the stresses and displacements at any or all instants during the time of the event.

Accupak/VE's Monitor virtual instrumentation program shows results graphically during run time. The Monitor program can show displacement, velocity, acceleration, frequency response, reaction forces and maximum stresses versus time as the event unfolds. Also available is an onboard FFT (Fast Fourier Transform) analyzer that converts displacement versus time into frequency versus energy so design engineers can see the energy absorption spectrum of the model during the event.

For more information on Accupak/VE for Mechanical Event Simulation, contact us or visit our web site at www.algor.com.

Answer: 56.6 lb



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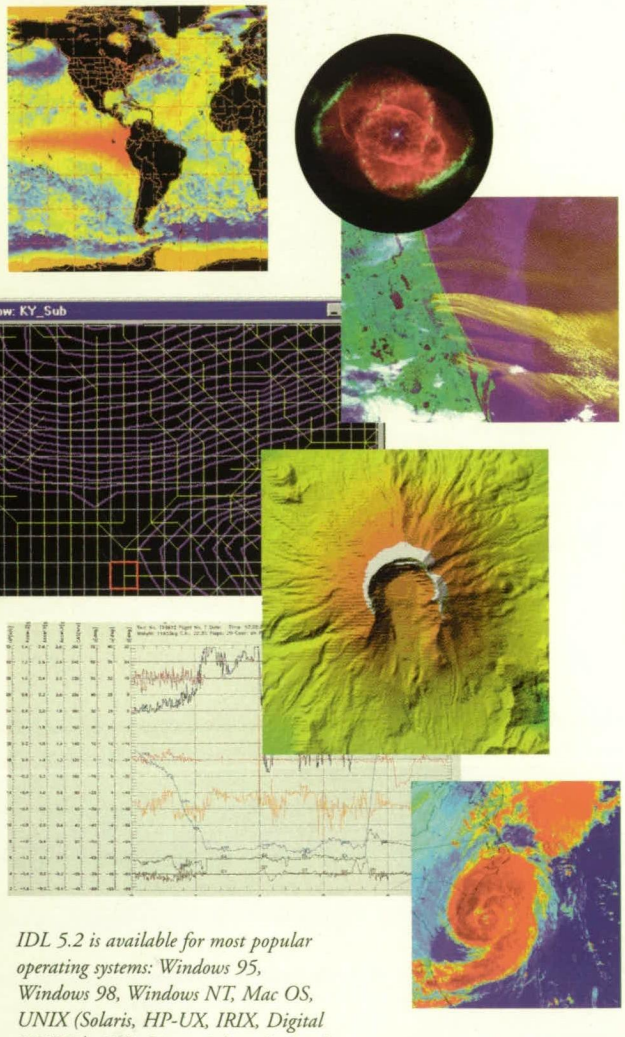

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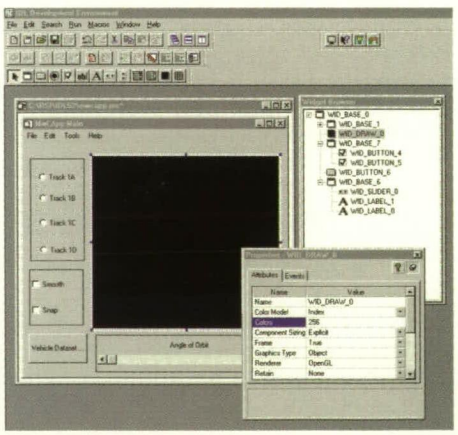

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